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# The Graduate School

## 1970-71

Volume LXI, Number 7, January 1970

The Bulletin of the University of New Hampshire is published monthly except in June. Second-Class postage paid at Durham, New Hampshire 03824.

# University Calendar 1970-71

## Semester I

September 13, Sunday  
September 14, Monday  
September 14, Monday  
September 15, Tuesday  
September 17, Thursday  
September 25, Friday  
October 7, Wednesday  
October 14, Wednesday  
November 6, Friday  
November 24, Tuesday  
November 29, Sunday  
November 30, Monday  
December 11, Friday  
January 3, Sunday  
January 4-15, Monday-Friday  
January 15, Friday

January 18, Monday  
January 28, Thursday  
January 28, Thursday  
January 31, Sunday

8 A.M. Residence halls open  
Registration  
4 P.M. First faculty meeting  
8 A.M. Classes begin  
1 P.M. Opening Convocation  
4:30 P.M. Last day to add courses  
First Graduate Faculty meeting  
Last date for partial refund on withdrawal  
4:30 P.M. Last day to drop courses  
7 P.M. Residence halls close, Thanksgiving  
2 P.M. Residence halls open  
8 A.M. Classes resume  
7 P.M. Residence halls close, Christmas  
2 P.M. Residence halls open  
Reading Period  
Last day for presenting Ph.D. dissertation at Graduate School Office if degree candidate in January  
8 A.M. Semester I final examinations begin  
6 P.M. Final examinations end  
8 P.M. Residence halls close  
Commencement

## Semester II

February 7, Sunday  
February 8, Monday  
February 9, Tuesday  
February 13, Saturday  
February 19, Friday  
March 10, Wednesday  
March 19, Friday  
March 28, Sunday  
March 29, Monday  
April 2, Friday  
April 12, Monday

May 7, Friday

May 10-21, Monday-Friday  
May 21, Friday

May 24, Monday  
May 31, Monday  
June 4, Friday  
June 4, Friday  
June 6, Sunday

2 P.M. Residence halls open  
Registration  
8 A.M. Classes resume  
Classes held, Monday schedule  
4:30 P.M. Last day to add courses  
Last date for partial refund on withdrawal  
7 P.M. Residence halls close  
2 P.M. Residence halls open  
8 A.M. Classes Resume  
4:30 P.M. Last day to drop courses  
Last day for filing application for 1971 Summer Session graduate scholarships  
Last day for presenting Ph.D. dissertation at Graduate School Office if degree candidate in June  
Reading Period  
Last day for final Ph.D. oral exam if degree is to be granted in June  
8 A.M. Semester II final examinations begin  
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Commencement



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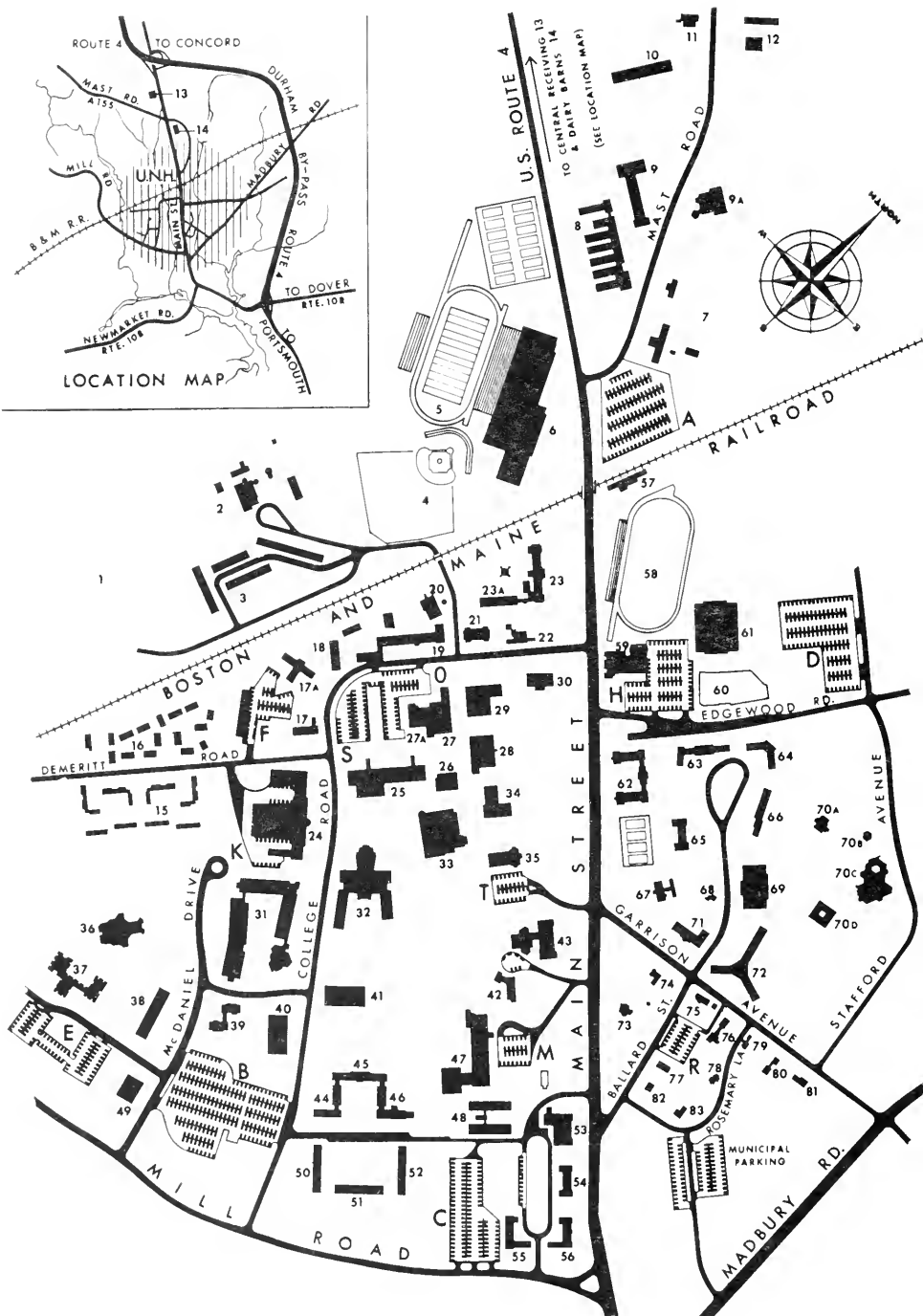
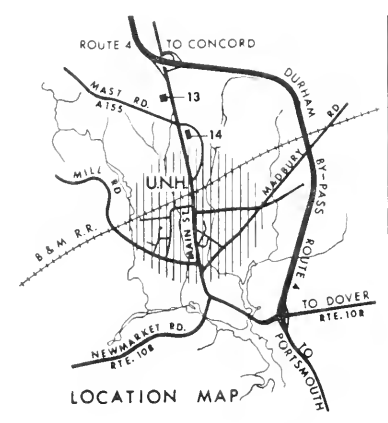
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# Graduate Education at the University of New Hampshire

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## Background

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The University of New Hampshire began its life as the “New Hampshire College of Agriculture and the Mechanic Arts” in 1866. Originally located in Hanover, the New Hampshire College moved to Durham in 1893. Here it developed more rapidly, aided by the substantial bequest of Benjamin Thompson. In 1923 the state granted its land-grant college a new charter as the University of New Hampshire. Five years later the Graduate School was formally added to the University system. The University now includes the following colleges and schools: College of Life Sciences and Agriculture, College of the Liberal Arts, College of Technology, Whittemore School of Business and Economics, the School of Health Studies, Thompson School of Applied Science, and the Graduate School. The University also includes as component parts the State Colleges located at Keene and Plymouth. The major thrust of graduate education is at the University campus in Durham.

Although the first Ph.D. was awarded in 1896, graduate education at the University had its formal beginnings forty years ago. The development of the graduate programs has been gradual and systematic with the quest being for academic excellence and for programming commensurate with institutional resources and regional opportunities. The Graduate School offers an environment where the search for knowledge and understanding can be stimulated and sustained. The graduate student is expected to make use of such opportunities and to demonstrate the maturity and self-discipline on which true scholarship is based.

The Graduate School is administered by the Dean of the Graduate School in association with the Associate Dean and Coordinator for Research; the Graduate Council serves in an advisory capacity. Graduate studies at the University are supervised by the Graduate Faculty.

### Locations and Facilities

---

Few institutions of higher learning are as ideally located as the University of New Hampshire. Durham is one of the oldest towns in northern New England, and traces of its colonial past are everywhere apparent. To the south, ninety minutes away, are metropolitan Boston and all the cultural opportunities a great urban area can offer. To the north, an equal distance in time, are the White Mountains and unsurpassed skiing, hiking, and scenery. Twenty minutes to the east are the beaches and rocky coasts of New Hampshire and Maine.

The University campus in Durham is 156 acres in size. There are 35 buildings devoted to administration, instruction, and research, and 24 residence halls for men and women. Book value of the physical plant exceeds \$53 million. Total University lands—including athletic fields, farms, and woodlands—comprise 3,075 acres.

Major construction projects of the past ten years include:

*University Library*, housing 500,000 volumes, 4,000 periodicals, and substantial microfilm and tape collections.

*Paul Arts Center*, a \$2,250,000 structure with separate wings for music, drama, and the arts.

*Social Science Center*, completed in 1968, has the Graduate School Offices and facilities for several departments in the Social Sciences.

*Spaulding Life Science Building*, with facilities for the departments of Biochemistry, Microbiology, and Zoology.

*Physical Education Facilities*, including an indoor track and pool and Snively Arena, an indoor hockey rink, have recently been completed at a cost of \$3,600,000.

*Whittemore School Building*, houses the business and economics departments with extensive facilities including computer equipment.

*Parsons Hall*, the first phase of which was completed in 1966, provided completely new facilities for the Department of Chemistry. The second phase of construction will be completed by the fall of 1970.

*Kendall Hall*, a five-story building completed in the spring of 1970, is the home of the Animal Sciences Department with offices, classrooms, and laboratories. The library for the College of Life Sciences and Agriculture and for Microbiology and Zoology is located on the first floor.

Other new buildings since 1946 include the University's engineering building, student recreation center, nutrition laboratory, thirteen residence halls, two dining halls, and housing for married students and faculty.

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### Student Activities

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Graduate student participation in University activities is substantial. The Graduate Student Senate is an independent organization representing all departments with graduate programs. Graduate students are often consulted by departments about academic decisions. Graduate students are elected. Three serve on the Graduate Council and representation also exists on the Research Council. The University's primary governing body in matters of student conduct and academic policy is the University Senate composed of 30 faculty members, 12 administrators, 5 graduate

students, and 30 undergraduates—all with equal voting privileges. This reflects the increased student participation in the University governing process.

Office space has been provided in the Graduate School for graduate-student representatives. There is also a large lounge and kitchen available to students for social and academic events.

The Afro-American Society participates actively in University affairs.

Information and counseling are available concerning a student's military obligation.

Durham has Episcopal and Roman Catholic churches, a Community Church, and a Unitarian-Universalist Fellowship. A synagogue, Friends meeting, and churches of other faiths are located in Dover.

A number of student organizations help promote religious life on the campus. There are clubs for Episcopal, Christian Science, Mormon, Jewish, Catholic, and Greek Orthodox students; a Christian Association with a full-time chaplain for protestant students; and an Inter-Varsity Fellowship.

Many of the over forty student organizations welcome graduate-student participation.

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## Teaching, Service, and Research

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The University of New Hampshire has a faculty of 620, including those who teach part-time. Their main function is teaching, but many—perhaps a majority—are also deeply involved in research and service activities.

Among the University's specialized research facilities are the *Space Science Center* in DeMeritt Hall, the *Ritzman Animal Nutrition Laboratory*, and the *Computation Center* in Kingsbury Hall.

One of the largest research and service units is the *Agricultural Experiment Station*, which conducts research, publishes results, and provides testing services for New Hampshire farmers. A similar service for New Hampshire industry is provided by the *Engineering Experiment Station*.

The *Cooperative Extension Service*, operating in conjunction with the U.S. Department of Agriculture, bridges the gap between campus research and the people of the state.

Formal adult education is conducted by the Division of Continuing Education, which offers credit and non-credit courses anywhere in the state where there is sufficient demand.

The University operates New Hampshire's educational television station, *WENH-TV*, broadcasting in-school programs for 110,000 young people, and, during the evening hours, cultural and educational programs.

Another major extension service of the University is the *New England Center for Continuing Education*. This facility houses research, conference and service activities for the entire six-state region.

Other University units which place its resources at the service of the state: the *Resources Development Center*, which brings the talents and techniques of the social scientist into closer partnership with state and local governments; the *Public Administration Service*, which specifically aids town and city officials; the *Water Resources Research Center*; and the *Bureau of Educational Research and Testing*.

The New Hampshire State Entomologist and State Geologist are University faculty members with offices on campus.

The *Engineering Design and Analysis Laboratory* is an interdisciplinary faculty group predominantly from the College of Technology. EDAL-associated faculty and graduate students participate mainly in marine-oriented engineering projects.

Among the many research instruments available are a Mass Spectrometer, an Optical Rotatory Dispersion Spectrophotometer, a Nuclear Magnetic Resonance Spectrometer, a Van der Graaff Generator, an Amino Acid Analyzer, and an Electron Spin Resonance Spectrometer. Students from all disciplines may make arrangements for their use.

The *Jackson Estuarine Laboratory*, the University's newest research facility, is an 8,400 square foot structure located about five miles from the University campus on the shore of the Great Bay at Adam's Point. The tidewater area in the Great Bay estuarine complex covers more than 15,000 acres. Tidal water enters and leaves via the Piscataqua River; some 13.5 billion gallons ebb and flow on an average tide of eight vertical feet. The continental shelf of the Gulf of Maine is within about thirteen miles steaming distance of the Laboratory. Marine research facilities for the departments of biochemistry, botany, microbiology, zoology, and geology will be contained in the Laboratory. Also included are: a circulating seawater system; a shop for maintenance of oceanographic gear; a small library-conference area; a research vessel, R/V "Jere A. Chase"; and a pier for docking research vessels.

The principal research topics of the Jackson Estuarine Laboratory are a study of the estuarine and continental shelf food-web, biotoxins from marine organisms, and pollution in the marine environment.

This project has received support from the National Science Foundation and the New England Regional Commission.

Further information about the above service activities may be obtained by writing the director of the appropriate unit, or from: the Director, Division of Industrial and Community Services, Schofield, Durham, N.H. 03824.

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## Cultural Activities

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A substantial range of cultural activities complements the regular academic program.

An outstanding program in music each year includes concerts and opera by student groups and recitals by faculty members. The University also sponsors a "Blue and White" concert series which brings professional musicians to the campus. In recent years, this series has included Eileen Farrell, the Boston Symphony Orchestra, and the Metropolitan Opera Studio.

Drama is offered several times during the year by the University Theater. There are professional productions in the "Allied Arts" series, which has included performances by Emlyn Williams, Richard Dyer-Bennet, and the Eric Hawkins dance company.

There are many public lectures at the University, by faculty and off-campus speakers. One lecture series brings outstanding men and women of arts, letters, science, and the humanities to the campus for a formal lecture and informal meetings with students. Another series concentrates on issues, and brings one or more note-

worthy public figures to speak on an important topic such as civil rights, population, and pollution. Recent visitors in this series have included Crane Brinton, Aaron Copeland, Robert Penn Warren, Arthur Kornberg, Margaret Meade, Hubert Humphrey, and a Black Power Symposium with James Strickland and Harold Hatcher.

In the galleries of Paul Creative Arts Center, there is a continually changing program of exhibits to interest both the art student and the layman.

Student groups are also active in promoting cultural and educational events. Newest of these student ventures is a film series. There is also a student FM radio station. Political clubs often bring speakers of national prominence to the campus.

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## University Services

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### The Counseling and Testing Center

The Counseling and Testing Center provides, without charge and through a professionally qualified staff, a range of psychological services to students who are experiencing a persistent personal or emotional difficulty or some disruption in their academic lives. Diagnostic services, with the assistance of a consulting psychiatrist, are also available to students; and when necessary, treatment planning and/or referral to outside sources are provided. The services of the office are not limited to those with severe problems but are geared to the needs of the typical college student.

### The University Health Service

The University Health Service, located in Hood House, is devoted to the protection, improvement, and maintenance of student health. Graduate students carrying nine or more credits and graduate assistants are eligible for treatment. A well equipped outpatient clinic functions for diagnosis and treatment of ambulatory patients; and a modern infirmary of twenty-six beds, with an isolation division for communicable diseases, is available for students who require inpatient care. During the regular academic year registered nurses are on duty at all times. Individual health guidance is given through personal conferences with the University physicians. Routine office hours of the University physicians are from 9:00 a.m. to 12:00 noon and 1:30 p.m. to 4:00 p.m. daily, except Saturdays and Sundays when emergency care is available. Bed patients at Hood House are charged \$5.00 per day.

The Health Service is closed when the University is officially closed for holidays, closing one hour after the dormitories, and opening at 3:00 p.m. on the day before classes resume. During the Summer Session, Hood House is open 24 hours a day with a limited staff on duty. A doctor is on call and nurses will decide when a doctor's attention is needed after hours.

Injury and illness which require hospital confinement, services of specialists, operations, special nurse, or special prescriptions are at the expense of the student.

In addition to the health service available through Hood House, group accident and sickness insurance, giving twelve-months coverage, is available to students at the University. This insurance coverage is designed to supplement the program of the University. Complete details may be had on application to the Business Office.

### The Memorial Union

The Memorial Union is a campus center for outside-the-classroom activities for the University community. It provides social, recreational, and educational meeting rooms; game rooms; and meals and snacks; it serves as headquarters for a number of student organizations. The Union staff reserves rooms for organizations to meet in the Memorial Union and in other University buildings and serves as a central source of campus information. A program of activities for all students is planned by the all-student board of governors of the Memorial Union Student Organization.

The Memorial Union is the gift of the citizens of New Hampshire, the students, the alumni, the faculty and staff, and other friends of the University. New facilities are being added at a cost of 1.3 million dollars. This will double the present cafeteria seating capacity and provide numerous rooms for student activities. The building serves three principal purposes: a living memorial to the men and women of the state of New Hampshire who have sacrificed their lives in our armed forces, a college union, and a state-wide conference center.

### The University Placement Service

The objective of University Placement is to assist students in obtaining permanent employment upon graduation from the University. The office maintains contact with recruiting personnel from business, industry, government, and education, and keeps up-to-date data on positions available as well as vocational information about employing organizations. The Service provides vocational counseling as an adjunct to the faculty-student relationship. An on-campus interview program is administered by the Service which brings recruiting personnel to the campus each year between November and April.

The services of University placement are also available to undergraduate and graduate students seeking summer employment during their years at the University.

University Placement also assists UNH alumni in their post-collegiate placement activities.

It is the policy of University Placement to provide students with information about employing organizations and to discuss particular employment opportunities with interested registrants. The final decision concerning a registrant's acceptance or rejection of an offer of employment, however, always rests with the registrant.

Registration is important and should be completed by the student while on campus, even though permanent employment is not sought immediately after graduation.

### Housing and Dining Services

*Babcock House*, completed in January 1968, is the graduate residence for single graduate students. Two, six-story towers, connected at each floor by a common lounge, accommodate 180 men and women. Facilities include a large lounge with fireplace, two recreation rooms, food-vending room, coin-operated laundry, TV room, ski storage, luggage storage, individual mail lock boxes, and private room phones if desired. The Faculty-Member-in-Residence and his family live in a two-bedroom apartment on the ground floor.

The residence rooms are all single rooms allowing complete privacy for consultation with students or faculty. Rooms are furnished with a bed, mattress, pillow, easy chair, desk chair, waste basket, and a built-in desk-dresser-wardrobe unit with

book shelves, mirror, medicine chest, and desk lamp. Residents provide their own bedding. An optional linen service is available furnishing bed linen, towels, and blankets. Linen and towels are laundered weekly. The charge for this service will be \$25 for linen and towels or \$31 for linen, towels, and two blankets.

Babcock house is located on College Road opposite Randall and Hitchcock residence halls. Parking space is available for graduate students. Although there will be no meal preparation in Babcock House, residents may elect to take a 21-meal contract and eat at any of the three campus dining halls for \$500 for the academic year. A 15-meal (Monday breakfast through Friday supper) contract may be purchased for \$440 for the academic year. Students who do not wish to take the contract may buy individual meals on a cash basis. The new *Philbrook* dining hall is nearest to Babcock House and offers quiet, small dining areas. The *University Dining Services* also operate a cafeteria in the Memorial Union where meals may be obtained normally on an a la carte plan.

As soon as a student is notified of his admission to the Graduate School, he may request a housing application and agreement. Please read carefully the housing agreement because it is binding for the entire academic year beginning in September and ending in June.

*Off-Campus Housing*—The University Residence Office maintains a partial listing of off-campus apartments, rooms, and houses within the immediate area of Durham. Because of the day-to-day changes in this list it is not feasible to send copies. A trip to Durham will usually prove more satisfactory. The Residence Office is open Monday through Friday, 8:00–4:30.

*On-Campus housing for married graduate students* is available in Forest Park, a complex of studio, one- and two-bedroom apartments. Telephone service is paid by the tenant and a lease is required. Heat and electricity are furnished.

Because of heavy demand for these facilities, the Residence Office encourages graduate students interested in Forest Park to apply a semester prior to intended occupancy. Studio apartments rent for \$82.50 per month; one-bedroom apartments, \$97.50; two-bedroom apartments, \$110 and \$125.

To obtain housing application forms, the student should write to the Residence Office, University of New Hampshire, Durham, New Hampshire 03824.

## Alumni Association

Those individuals who have received an advanced degree from the University of New Hampshire automatically become members of the Alumni Association. The present membership of the Association exceeds 29,000 men and women who represent New Hampshire College and University of New Hampshire classes from 1896 through the present. Alumni reside in every state of the Union and many foreign countries.

Governed by a Board of Directors of 15 elected and 4 ex officio members, who are the elected Alumni Trustees, the alumni are organized by classes and clubs. Class reunions are held annually. An annual Homecoming in the fall provides opportunity for alumni to return to Durham while the University is in session. Other alumni gatherings on campus are also scheduled from time to time during the academic year. There are 50 UNH alumni clubs throughout the United States. Two alternating bi-monthly publications, "The New Hampshire Alumnus" and "UNH Magazine" circulate news of students, faculty, alumni, and the University. From offices in Alumni House on the campus, the Association's activities are directed by Director of Alumni Affairs and his staff.





# Regulations of the Graduate School

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## General Regulations

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### Admission

Admission to the Graduate School may be granted to graduates of all colleges and universities of approved standing, provided their undergraduate records are satisfactory. Factors of race, religion, color, and national origin do not enter into the admissions process.

Before entering upon graduate work the applicant must present evidence that he has had the necessary prerequisite training which will enable him to pursue the courses desired. A candidate for admission must have a superior undergraduate record. Where the department in which the candidate plans to do his work so requires, the candidate may be required to take an achievement test. In addition there may be special requirements set up by individual departments or programs. For the individual departmental requirements, see the description under the departmental offerings in this catalog.

A student who desires to register for graduate study must submit to the Dean of the Graduate School the official application for admission to graduate study. Forms for this purpose may be obtained by writing to the Dean of the Graduate School, University of New Hampshire, Durham, New Hampshire 03824. The application must be accompanied by two official transcripts of the student's undergraduate work and of any previous graduate work, and by three letters of reference. Transcripts of applicants who are admitted to graduate study become a permanent part of the University files and will not be returned.

Applications to the University of New Hampshire Graduate School must be accompanied by a non-refundable \$10 application fee.

Students wishing to enroll in the Master of Science for Teachers program must meet one of the following admission requirements: (a) education courses sufficient for certification, (b) three years' experience in teaching, or (c) current full-time participation in teaching.

Completed applications for admission to the Graduate School should be submitted before July 15 for the first semester, before November 15 for the second semester, and before April 1 for the Summer Session to guarantee action before the respective registration days. Applications will be accepted after the dates mentioned above, provided that the applications are accompanied by complete official transcripts; but it may be necessary to postpone the evaluation of credentials and the determination of requirements until after the registration period. Students wishing to apply for financial aid must submit their applications for admission prior to February 15.

Foreign students applying for admission to the Graduate School must furnish proof of their ability to handle the English language. Such students should take the "Test of English as a Foreign Language" administered by the Educational Testing Service, Princeton, New Jersey. All regularly enrolled graduate students must have a medical history and physical examination report on file with the Director of the University Health Service. Recent graduates of the University of New Hampshire need not file a new set of reports upon being admitted to the Graduate School. Others should obtain the proper forms from the Dean of the Graduate School.

Admission to the Graduate School does not imply admission to candidacy for a degree. No graduate student is admitted to candidacy for a degree until he has been in residence a sufficient length of time to enable his instructors to judge his ability to carry on graduate work. Generally this period of time shall be not less than that required for the completion of 12 credits of graduate work for the Master's degree, and the passing of the qualifying examination and the completion of departmental language requirements for the Ph.D. degree. Admission to candidacy for a degree will be determined by the Dean upon the recommendation of the department concerned. The student will be notified by the Dean, in writing, of the decision made.

A student admitted to graduate study must have his program approved by the chairman of his department or of his guidance committee and the Dean of the Graduate School. Registration is held prior to the beginning of classes each semester and on the first day of Summer Session. Consult the calendar in this catalog for the dates of registration. Graduate students are defined as those who meet the requirements for admission to the Graduate School and are registered for an approved program for graduate credit.

The maximum graduate load allowed is 16 semester credits for a regular semester, 4 credits for a 4-week Summer Session, and 8 credits for an 8-week Summer Session. Only under unusual circumstances will extra credits be allowed, and then only with the approval of the Dean of the Graduate School.

### Graduate Credits

Graduate credits may be earned only in courses numbered from 700 through 898, and in the thesis, but graduate credits will not be given in any courses so numbered which are open to freshmen or sophomores. For certain cases graduate credit is allowed for 600-level courses for Master's degree programs.

Also upon recommendation of the department, superior students may be allowed to count credits from up to two 300-level courses toward both a Bachelor's and Master's degree provided the student has been admitted to the Master's program.

Graduate students who desire to do a part of their work during the Summer Session of the University will find graduate courses offered in many departments. Credit in appropriate courses may be used in fulfilling the requirements for an advanced degree. For complete information on the Summer Session, see the Summer Session catalog.

Qualified senior students in the University of New Hampshire may be admitted to the Graduate School, and must have been admitted before taking courses for graduate credit.

Students holding the baccalaureate degree who have not been admitted to the Graduate School, but who wish to register for graduate courses, must receive the approval of the Dean of the Graduate School and of the instructor concerned.

Credits earned in an unclassified status will be applied to a degree program on a selective basis. No more than nine hours earned on campus in an unclassified status may be applied at a later date to the residence or credit-hour requirement for a degree.

An incomplete grade in the Graduate School must be made up within a year after the course was to have been completed. This rule does not apply to the completion of the thesis. The student must meet the special requirements of the department in which he is doing his graduate work, and his program must be approved by his adviser and the Dean of the Graduate School. For these special requirements see the department statements in this catalog.

There are changes being made regarding graduate requirements and catalog material is subject to revision.

### Graduate Grades

The three passing grades are: Honors (*H*), High Pass (*HP*), and Pass (*P*). A graduate student receiving nine or more credits with a failing grade (*F*) will normally be required to withdraw from the Graduate School. Students enrolled in Master's programs requiring in excess of thirty credits will be permitted a proportional increase in the amount of failing work. A grade of Credit (*Cr*) is given for completed theses and dissertations.

### Tuition

The tuition is \$810 a year for residents of New Hampshire and \$1,775 a year for non-residents. A student, though he may be 21, will not be recognized as a resident by the University unless he can clearly establish that his residence in New Hampshire is for some purpose other than the temporary one of obtaining an education at the University.

Tuition rates in the Summer Session and for courses offered by the University Extension Service are listed in their respective catalogs. It should be noted that liberal financial aid is available to graduate students.

Any student registering for 9 credits or more per semester will pay the full semester tuition. Any student registering for fewer than 9 credits per semester shall pay \$30 per credit hour. Graduate assistants may be exempted from payment of tuition.

A doctoral student who is registered for fewer than nine credits and is pursuing research for the dissertation shall pay by the credit hour, plus a research charge of \$50 a semester. If registered for research only, the charge of \$50 a semester will be applicable and will carry with it the privilege of attending seminars.

When a doctoral candidate completes his requirements *in absentia*, a charge of \$50 for the privilege of taking the final examination must be paid six weeks before the conferring of the degree. A Memorial Union assessment of \$12.50 per semester must be paid by each student.

## **Regulations of the Graduate School**

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The immediate families of members of the University staff may register as full or part-time students in the Graduate School at one-half the current tuition or course rate. They are required, however, to pay the full research fee, if doctoral students.

The University reserves the right to adjust charges for such items as tuition, board, and room rent from time to time. Such changes will be held to a minimum and will be announced as far in advance as feasible.

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## **Assistantships, Scholarships, and Fellowships**

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### **Graduate Assistantships**

Approximately 200 graduate assistantships are available each year. Such assistantships are awarded only to superior students. The reappointment of a graduate assistant is contingent on the maintenance of a high level of scholarship. The service required of the graduate assistant may be in the nature of teaching or research assistance. The normal academic load is three full courses per semester.

There are four types of regular assistantships available with the possibility of additional summer employment.

Net stipends for graduate assistantships vary up to a maximum of \$2800 per academic year and \$3920 for the calendar year plus tuition waiver. The following types of graduate assistantship appointments are available:

Teaching Assistant—classroom teaching.

Laboratory Assistant—laboratory preparation or discussion section.

Research Assistant—assisting faculty in their research projects.

Project Assistant—assist faculty in externally funded research.

Inquiries regarding assistantships should be addressed to the chairman of the department concerned.

### **Graduate Associates**

A very limited number of appointments are available for highly qualified teaching and research personnel whose normal academic program would not exceed one full course per semester. Stipends are negotiable, up to \$5,000, according to qualifications and duties.

### **Tuition Scholarships**

Up to fifty superior students may be granted academic-year tuition scholarships. These awards are subject to the maintenance of a high scholastic record in the Graduate School. Foreign students will be considered for these scholarship awards.

Up to thirty superior students, who have been regularly admitted to the Graduate School, may be granted tuition scholarships for the Summer Session.

### **University of New Hampshire Fellowships**

A limited number of three-year fellowships, called University of New Hampshire Fellowships, are awarded to outstanding doctoral students. Each recipient is given an opportunity to spend the first year in full-time study, the second year as a teaching assistant, and the third year as a research assistant. The stipends for this program

are \$2,400 for the first year, \$2,600 for the second year, and \$2,800 for the third year. In addition, the award provides \$680 support for each of two summers, waiver of tuition, and an annual allotment of \$500 each for as many as two dependents.

### Alumni Fellowships

A limited number of Alumni Fellowships is available to students following a graduate program in the social sciences and humanities. The stipend is \$3,000 per academic year plus tuition waiver.

### Traineeships

Traineeships sponsored by the National Science Foundation are available to outstanding students studying for the Master's or Ph.D. degree in the various science and engineering fields. The basic stipends (for 12 months of study) range from \$2,400-\$2,800 plus free tuition and \$500 per dependent.—Open to U.S. citizens only.

### National Defense Education Act (NDEA Title IV) Fellowships

National Defense Education Act (NDEA Title IV) teaching fellowships are available to highly qualified students who are studying for the Ph.D. degree and are interested in college teaching careers. Annual (12 months) stipends range from \$2,400 to \$2,800 plus free tuition and \$500 per dependent.—Open to U.S. citizens only. Graduate students also are eligible for awards granted by other national agencies and foundations.

### Martin Luther King Scholarship

There are two Martin Luther King Scholarships reserved for graduate students. They are to assist members of minority groups. Stipend amounts vary according to financial need.

### Dissertation Fellowships

One-year dissertation fellowships are available, providing a \$3,000 stipend. Because no classes are attended, a tuition waiver is not included.

### Summer Fellowships

Thirty Summer Fellowships for Teaching are available for students who have held teaching assistantships during the previous academic year. The stipend for summer study is \$750.

Information and application forms for all of the above scholarship and fellowship programs may be obtained from the Dean of the Graduate School.

Properly qualified scholars, who may temporarily desire the privileges of the library and research facilities of the University and who are not candidates for a degree, may, upon recommendation of the Dean of the Graduate School and the approval of the President of the University, be appointed Honorary Fellows without stipend. Honorary Fellows shall not be required to pay any charges except possibly the cost of unusually expensive supplies or equipment.

## **Graduate Degree Programs**

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### **Master of Science**

Animal Sciences  
Biochemistry  
Biology  
Botany  
Chemical Engineering  
Chemistry  
Civil Engineering  
Electrical Engineering  
Entomology  
Forest Resources  
Genetics  
Geology  
Home Economics  
Mathematics  
Mechanical Engineering  
Microbiology  
Music Education  
Physics  
Plant Science  
Resource Economics  
Soil and Water Science  
Zoology

### **Master of Arts**

Economics  
English  
French  
German  
History  
Music  
Political Science  
Psychology  
Sociology  
Spanish

### **Master of Arts in Teaching**

Department of Education

### **Master of Science for Teachers**

Chemistry  
English  
French  
German  
Mathematics  
Physics  
Spanish

### **Master of Agricultural Education**

Department of Agricultural Education

### **Master of Business Administration**

Whittemore School of Business  
and Economics

### **Master of Education**

Department of Education

### **Master of Public Administration**

Department of Political Science

### **Doctor of Philosophy**

Biochemistry  
Botany  
Chemistry  
Engineering  
English  
Genetics  
History  
Mathematics  
Microbiology  
Physics  
Plant Science  
Psychology  
Sociology  
Zoology

## Requirements for Master's Degree

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For the degrees of Master of Arts, Master of Science, Master of Agricultural Education, Master of Business Administration, and Master of Public Administration, at least 30 credits must be earned, including a minimum of eight credits in courses, not including thesis, numbered 800-898. Courses numbered 600-699 cannot be used towards these Master's degrees if the courses are given in the department awarding the degree. No more than 12 credits will be permitted in courses numbered 600-699. The major department will prescribe for its students the courses which make up the degree program. Somewhat different requirements obtain for the Master of Science for Teachers degree and it is recommended for this degree, as well as for all other Master's degrees, that the appropriate departmental section of the catalog be consulted.

A student will normally spend at least one calendar year, or the equivalent, in satisfying the requirements for the degree. No more than 12 credits, not including thesis, may be earned off campus. Of these 12, only 6 may be from another graduate school.

All graduate work for any Master's degree must be completed in not more than six years from the time of registration for the first work taken for the degree.

In any department or program requiring a final examination for the Master's degree, the examination may be oral, written, or both. A candidate will be permitted only two opportunities to take the final examinations for the Master's degree, and the time of these examinations will be at the convenience of the department concerned, except that all such examinations must be given at least two weeks before the Commencement date in the year in which the degree is to be conferred. Further regulations governing the final written examination, when required, will be made by the department concerned, subject to the approval of the Dean of the Graduate School. Oral examining committees, when required and not otherwise provided for, will be appointed by the Dean of the Graduate School, upon the recommendation of the department concerned. The Dean of the Graduate School is, ex officio, a member of all examining committees.

A student may present for credit a maximum of six credits earned at another graduate school, provided that these credits are of a grade of at least B or the equivalent. These will be applied toward the degree only if approved by the major department and the Dean of the Graduate School.

### Thesis

A thesis may be required of candidates for the Master of Arts or the Master of Science degrees. Consult the departmental statement for thesis requirements. The thesis must be approved by a committee, comprising the instructor under whose direction it was written and two other members of the Graduate Faculty selected by the department chairman and approved by the Dean of the Graduate School.

Each department will determine the date when the candidate must submit for approval a statement of the subject of the thesis and the date when the thesis must be completed.

The number of thesis credits may vary from six to ten, subject to the approval of the student's adviser. No thesis credit shall be given until the completed thesis has been approved by the committee on the thesis. No letter grade shall be given for the thesis, but its satisfactory acceptance will be recorded with a Cr (credit).

## Regulations of the Graduate School

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The student should obtain from the Graduate School office the latest mimeographed regulations for the form and typing of thesis.

Whenever a thesis is printed, it must be designated as having been accepted as a Master's thesis by the University of New Hampshire.

Two copies of the approved thesis, ready for binding, shall be submitted to the Graduate School office not less than two weeks before Commencement, together with a receipt for the binding fee from the University Bookstore. Most departments require one copy of the thesis in addition to the above-mentioned two copies. (See departmental requirements in this catalog.)

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## Requirements for the Doctor's Degree

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The degree of Doctor of Philosophy is conferred on qualified candidates: who have passed an oral or written examination on the subject matter of their field of study, who have completed an original investigation in this field and have embodied the results in an acceptable dissertation, and who have passed an oral examination in defense of the dissertation. The degree of Doctor of Philosophy is essentially a research degree. It is not given merely for the completion of course credits. Graduate programs leading to the degree of Doctor of Philosophy are offered in Biochemistry, Botany, Chemistry, English, Engineering, Genetics, History, Mathematics, Microbiology, Physics, Plant Science, Psychology, Sociology, and Zoology.

All resident predoctoral students must register each semester until requirements for the degree have been completed. The minimum requirement for the doctorate is three years beyond the bachelor's degree. Resident graduate work done at other universities may be counted toward the minimum requirement upon approval of the guidance committee and the Dean of the Graduate School, but one full academic year must be in residence at the University of New Hampshire. In individual cases, the major department and the Dean of the Graduate School may grant permission to pursue the research for the dissertation at another institution where access to special facilities may be advantageous.

All graduate work for the doctorate must be completed by the end of the fifth academic year following that in which the student completes the requirements for advancement to candidacy.

### General Requirements

A student working for the Ph.D. degree must earn a passing grade in all the courses required by his guidance committee. Certain courses may be taken for audit.

When the student declares his intention to proceed to candidacy for the degree of Doctor of Philosophy, the department of intended major concentration shall notify the Dean of the Graduate School, who then, upon recommendation of the department, will appoint a guidance committee. This committee will assist the student in outlining his program and in preparing him for his qualifying examination. To prepare him for the qualifying examination and successful pursuit of his research and course work, the guidance committee may require him to take additional course work, with or without credit.

At the time of application by the student for the qualifying examination, a doctoral committee will be appointed to supervise the qualifying and final examina-



tions and to pass on the dissertation. This committee shall be nominated by the department of major concentration and appointed by the Dean of the Graduate School. It shall consist of a minimum of five members, usually three from the major department and two from related departments, and the Dean of the Graduate School, *ex officio*.

The qualifying examination may be written, oral, or both. This examination will test: (1) the student's general knowledge in his major and minor work and (2) his fitness for engaging in research, particularly in the subject proposed for the dissertation. The results of the examination will be communicated by the chairman of the major department to the Dean of the Graduate School.

The student may not be advanced to candidacy for the Ph.D. until he has passed the qualifying examination and such language or proficiency requirements as are deemed desirable by the major department. The proposed subject of the student's dissertation must be declared at the time of application for advancement to candidacy.

Resident full-time members of the University of New Hampshire faculty with rank of Assistant Professor or higher may not be admitted to candidacy for the Ph.D. at this University.

The dissertation must be a contribution to knowledge, embodying the results of significant and original research, and a mature and competent piece of writing.

A copy of the completed dissertation must be made available to the Dean of the Graduate School and to the members of the examining committee two weeks before the final examination date. Following the examination and two weeks prior to Commencement, two copies of the approved dissertation, ready for binding, shall be turned in to the Graduate Office, together with a receipt for the binding fee from the University Bookstore. Publication of the dissertation by University Microfilms will be required, and the cost will be assumed by the student. If the material presented in the dissertation is published, it should be designated as having been accepted as a doctoral dissertation by the University of New Hampshire.

The final oral examination is conducted by the doctoral committee and is intended to give the candidate an opportunity to defend his dissertation. A written final examination, on subject matter not covered in the qualifying examination, may also be required. This written examination is conducted by the major department. The final examinations must be completed at least two weeks prior to the date of receiving the degree. After consultation with the major department, the Dean may appoint, for participation in the final oral examination, additional members of the faculty under whom the student has worked. The doctoral committee alone shall decide on the merits of the candidate's performance by a majority vote.

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## Explanation of Course Numbering System

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The title, in capital letters, and the Arabic numeral designate the particular course. Odd numerals indicate courses normally offered in the first semester; even numerals indicate courses normally offered in the second semester. Numerals enclosed in parentheses indicate that course is repeated in the semester following. Thus course 401 (401) is offered in the first semester and is repeated in the second semester. Parentheses are also used to designate courses out of semester sequence. For example, (404) indicates an even-numbered course offered in the first semester.

## Regulations of the Graduate School

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The course description is followed by the prerequisites, if any, and the number of semester credits the course will count in the total required for graduation. Laboratory periods are usually two and one-half hours in length, lectures either 50 minutes or 80 minutes in length.

If the course numerals are connected by a hyphen, the first semester, or its equivalent, is a prerequisite to the second semester. If the numerals are separated by a comma, properly qualified students may take the second semester without having had the first.

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## IBM Key Codes

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The following numbers are used extensively in machine-processed data to identify both undergraduate and graduate programs offered at the University. An asterisk preceding the number identifies those departments which offer graduate programs.

### College of Liberal Arts

- 40 Liberal Arts non-departmental
- \*41 Biological Sciences Division
- 42 Education Division
- 43 Humanities Division
- 44 Physical Sciences Division
- 45 Social Sciences Division
- 46 The Arts
- \*47 Microbiology
- \*48 Education
- \*49 English
- 50 Geography
- \*51 Geology
- \*52 Government
- \*53 History
- 54 Nursing
- 55 Foreign Language and Literature
- \*56 French
- \*57 German
- 58 Greek
- 59 Italian
- \*60 Latin
- 61 Russian
- \*62 Spanish
- \*63 Music
- \*64 Music Education
- 65 Occupational Therapy
- 66 Philosophy
- \*67 Psychology
- \*68 Sociology
- 69 Speech and Drama
- \*70 Zoology

### College of Agriculture

- 20 Agriculture non-departmental
- \*21 Resource Economics
- \*22 Agricultural and Extension Education
- \*23 Soil and Water Science
- \*25 Animal Sciences
- \*26 Biochemistry
- \*27 Botany
- \*29 Entomology
- \*30 Forestry
- \*31 Home Economics
- \*32 Plant Sciences

### College of Technology

- 79 Technology non-departmental
- \*80 Chemical Engineering
- \*81 Chemistry
- \*82 Civil Engineering
- \*83 Electrical Engineering
- \*84 Mathematics
- \*85 Mechanical Engineering
- \*86 Physics

### Whittemore School of Business and Economics

- \*71 Business Administration
- \*72 Economics
- 74 Hotel Administration

# Departmental Requirements and Course Descriptions

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## Agricultural Education (22)

Chairman: *William H. Annis*

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ASSOCIATE PROFESSORS: William H. Annis, Paul A. Gilman, Jesse James

The degree of Master of Agricultural Education is designed for teachers of agriculture, county Cooperative Extension Service personnel, and others in adult education. A comprehensive examination will be required of all candidates for this degree.

### **783. Preparation for Conducting and Supervising Adult Education Programs**

The techniques of adult education in terms of: identifying needs, program planning, methods of teaching, supervision, and evaluation. Prerequisite: Agricultural Education 650, Principles of Agricultural Education, or permission of instructor. 4 credits.

### **785. Advanced Methods and Materials of Instruction**

The organization of instruction to meet individual and student needs; development and use of resource files and instructional materials. Evaluation in teaching vocational-technical education. Open to teachers of vocational-technical education and others by permission of instructor. 4 credits.

### **786. Concepts of Vocational-Technical Education**

The development of vocational-technical education in the United States with emphasis on the socio-economic influences responsible for its establishment. The federal and state requirements for programs on the secondary and post-secondary schools will be discussed. Coordination of programs with general education and other vocational fields. 4 credits.

### **791. Planning for Teaching**

The organization of materials of instruction to meet group and individual needs. Techniques of instruction, planning for teaching, the function of consulting committees, working with youth groups, and program evaluation. Prerequisite: permission of instructor. 4 credits.

**796. Investigation in (1) Vocational Education, (2) Extension Education, (3) Adult Education**

An opportunity is provided for a student to study a special problem in one of the areas listed. Elective after consultation with the instructor. Hours to be arranged. 2 or 4 credits. May be repeated.

**801. Advanced Methods in Agricultural Mechanics Instruction**

Agricultural mechanics problems and how to approach them in the high school as a part of the course of study in vocational agriculture. The physical setup, as well as the processing of supplies and equipment, methods of supervision and direction of agricultural-mechanics projects, and the preparation and presentation of demonstrations. Mr. Gilman. 2 credits.

**802. Methods of Teaching Power and Machinery in Agricultural Education**

Teaching the servicing and maintenance of the agricultural power and machine complex as it relates to the production and non-production phases of vocational agriculture. The development of teaching plans, techniques of instruction, and the development of multi-media teaching units will be stressed. 3 credits.

**804. Program Planning in Agricultural Education**

The basic problems, principles, and procedures in the process of program planning in vocational agriculture and extension. 2 credits.

**805. Planned Agricultural Experience Programs in Vocational Agriculture**

Development of cooperative relations, selection and development of individual programs with the students, and the supervision and evaluation of such programs. 2 credits.

**806. Preparation and Use of Visual Aids for Agricultural Education**

The purpose of visual aids and the kinds best adapted to use in the program, together with their preparation and use. 2 credits.

**807. Organization and Supervision of Youth Organizations**

The purposes and organization of youth organizations, establishing the local organization, planning and developing a program of work, ways and means of improving the local organization, and methods of evaluation. 2 credits.

**809. Community Organization and Public Relations**

The composition, purposes, and objectives of the various social and economic organizations operating in local communities. The importance of their membership to the general welfare of the area and the development of a public relations program. 2 credits.

**(895). Independent Study in Agricultural Education**

Individual study problems in various phases of agricultural education. Prerequisite: permission of staff. 2-6 credits. May be repeated.

**899. Master of Agricultural Education Thesis**

6-10 credits.

## Animal Sciences (25)

Chairman: *W. C. Skoglund*

PROFESSORS: Fred E. Allen, Hilton C. Boynton, Walter M. Collins, Nicholas F. Colovos, William R. Dunlop, Richard C. Ringrose, Winthrop C. Skoglund, Richard G. Strout

ASSOCIATE PROFESSORS: Alan C. Corbett, James B. Holter, Herbert C. Moore, James T. O'Connor, Gerald L. Smith, Samuel C. Smith

ASSISTANT PROFESSORS: Gene B. Fuller, Larry L. Stackhouse

To be admitted to graduate study in Animal Sciences an applicant is expected to have had sufficient undergraduate training in the basic biological sciences to qualify for special work in this field. A thesis is required, and a candidate for the Master's degree shall pass an oral examination covering his graduate courses and thesis.

### 701. Physiology of Reproduction

A study of physiology, embryology, endocrinology, reproduction, and lactation in domestic animals. Mr. Fuller. 3 lectures; 1 laboratory; 4 credits.

### 705. A Review of Animal Science

The principles and practices relating to the feeding, breeding, selection, and management of beef cattle, horses, sheep, and swine. For teachers of vocational agriculture and other students with the permission of their advisers. Staff. (Summer Session only.) Two hours daily, lecture and laboratory; 2 credits.

### 706. A Review of Dairy Science

Subject matter covering the principles and practices relating to the latest information on dairy cattle breeding, feeding, and management, and the processing and marketing of milk and its products. For teachers of vocational agriculture and other students with the permission of their advisers. Staff. (Summer Session only.) Two hours daily, lecture and laboratory; 2 credits.

### 707. A Review of Poultry Science

The principles and practices relating to the latest information on poultry breeding, feeding, diseases, and management. For teachers of vocational agriculture and other students with the permission of their advisers. Staff. (Summer Session only.) Two hours daily, lecture and laboratory; 2 credits.

### 708. Animal Genetics

Mendelian and quantitative inheritance in animals. Principles and systems of selection. Mr. Collins. Prerequisite: one course in genetics or permission of instructor. 2 lectures; 1 laboratory; 4 credits.

### 710. Ruminant Nutrition

Basic ruminant nutrition and feeding management, including the feeding of young ruminants, with the objective of economical milk production. Mr. Holter. 3 lectures; 1 laboratory; 4 credits.

## **795-796. Investigations in Dairy, Livestock, Poultry**

### **1. Genetics**

Mr. Gerald Smith, Mr. Collins, Mr. Boynton.

### **2. Nutrition**

Mr. Gerald Smith, Mr. Ringrose, Mr. Colovos, Mr. Holter.

### **3. Management**

Mr. Skoglund, Mr. Gerald Smith, Mr. Boynton.

### **4. Diseases**

Mr. Allen, Mr. Corbett, Mr. Dunlop, Mr. Strout, Mr. Samuel Smith.

### **5. Products**

Mr. Gerald Smith, Mr. Moore.

### **6. Light Horsemanship**

Mrs. Briggs, Mr. O'Connor.

### **7. Physiology**

Mr. Fuller.

An opportunity is given for the student to select a special problem in any of the fields listed under the guidance of the instructor. Elective only after consultation with the instructor in charge. Hours to be arranged. 2 credits. May be repeated.

## **801. Advanced Animal Breeding**

Practical breeding problems with beef and dual-purpose cattle, sheep, horses, and hogs. The genetic principles important to successful livestock production. Mr. Gerald Smith. 2 lectures; 1 laboratory; 3 credits.

## **802. Meats, Livestock Markets, and Products**

The essential factors in meat selection, cutting, curing, and smoking; study and discussion relative to the problems of livestock marketing and the procedure in the large central markets. Trips are taken to various packing plants. Mr. Gerald Smith. 3 lectures; 1 laboratory; 4 credits.

## **803. Advanced Animal Nutrition**

Incidental lectures, assigned reading, and laboratory practice in methods of research with major emphasis on protein and energy metabolism. Mr. Colovos. 3 credits.

## **804. Advanced Dairy Cattle Breeding**

The analysis and formulating of breeding programs, principles of milk secretion, and factors influencing the quantity and quality of milk. Mr. Boynton. 2 lectures; 1 laboratory; 3 credits.

## **805-806. Avian Microbiology**

The disease process (acute or chronic) in the intact host at cellular levels when invaded by viruses or virus-like agents, fungi, and protozoans. Physiological and cytopathological changes in tissue culture. Mr. Dunlop, Mr. Strout, and Mr. Corbett. Prerequisite: Animal Science 612 or the equivalent. 3 credits.

## **807-808. Avian Histopathology**

First semester: general histopathology. Second semester: the special histopathology of common diseases with emphasis on correlation of light and electron microscopy of tumors and tumor formation. Mr. Dunlop and Mr. Strout. Prerequisite: histology or the equivalent. 3 credits.

**809-810. Advanced Poultry Nutrition**

Metabolism and the physiology of digestion with emphasis on nutrient needs and deficiency diseases of poultry. Analysis of recent experimental research and current feed problems. Mr. Ringrose. 3 credits.

**811. Quantitative Genetics and Animal Improvement**

Gene frequency, genetic and environmental variation, heritability, fitness, selection, inbreeding, outbreeding, correlated characters. Mr. Collins. Prerequisite: 1 course each in genetics and statistics. 3 credits.

**897-898. Animal Science Seminar**

A survey of recent literature and research in the animal sciences. Staff. 1 credit. May be repeated.

**899. Thesis**

Hours and credits, from 6-10, to be arranged.

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**Biochemistry (26)**

Chairman: *Edward J. Herbst*

PROFESSORS: Donald M. Green, Edward J. Herbst, Miyoshi Ikawa, Arthur E. Teeri

ASSISTANT PROFESSORS: Gerald L. Klippenstein, James A. Stewart

Students admitted to graduate study in the Department of Biochemistry should have completed basic courses in chemistry, biological sciences, mathematics, and physics. The candidate for the Master of Science degree will be required to prepare a thesis, and to pass an oral examination on the thesis and on graduate courses prescribed for the degree program.

The Doctor of Philosophy degree candidate will be required to complete a dissertation on original research in biochemistry and to pass examinations supervised by the Doctoral Committee. Each candidate will be expected to demonstrate a broad basic knowledge of the field of biochemistry and to pass a reading proficiency examination based on the biochemical literature in German, French, or Russian.

**656. Physiological Chemistry and Nutrition**

An introductory biochemistry course with emphasis on human physiological chemistry and nutrition. The laboratory includes a study of procedures basic to chemical methods used in medical diagnostic work. Mr. Teeri. Prerequisite: satisfactory preparation in organic chemistry. 3 lectures; 1 laboratory; 4 credits.

**751. Principles of Biochemistry**

The fundamental principles of biochemistry with emphasis on the chemical properties; metabolic pathways; and functions of carbohydrates, lipids, and nitrogenous compounds. Mr. Herbst, Mr. Ikawa, and staff. Prerequisite: one year of organic chemistry or permission of instructor. 4 lectures; 1 laboratory; 4 credits.

**752. Topics in Biochemistry**

A detailed consideration of metabolism and of current developments in biochemistry. Staff and guest lecturers. Prerequisite: Biochemistry 751. 2 lectures; 2 credits.

**762. Plant Metabolism**

The function, occurrence, synthesis, and degradation of plant constituents. Emphasis is placed on respiration and photosynthesis and the metabolism of nitrogenous and aromatic compounds. Biochemical mechanisms such as those involved in seed dormancy, fruit ripening, and disease resistance are discussed in relation to their roles in plant survival. Mr. Routley. Prerequisite: general biochemistry. 2 or 4 credits.

**770. Biochemical Genetics**

The biochemical mechanisms of storage, replication, transmission, transcription, recombination, mutation, and expression of genetic information by cells and viruses. Mr. Green. Prerequisite: Biochemistry 751 or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

**795, 796. Investigations in Biochemistry**

Staff. Prerequisite: permission of instructor. Subject matter and hours to be arranged. 2 credits.

**811. Biochemistry of Lipids**

The chemistry, metabolism, and function of lipids. Mr. Smith. Prerequisite: general biochemistry. 2 credits.

**831. Cell Surfaces and Exoproductions**

A study of biochemical substances and events which occur at the surface of or outside the cell and how they influence cell-environment and cell-cell interactions. Subject matter includes the biochemistry of cell walls, extracellular polysaccharides and proteins, biotoxins, antibiotics, and hormones. Mr. Ikawa. Prerequisite: general biochemistry. 2 lectures; 2 credits.

**842. Biochemistry of Development**

An examination of the biochemical events underlying embryonic development and cellular differentiation. Special emphasis will be placed on the role of nucleic acid and protein synthesis in regulating these processes. Mr. Stewart. Prerequisite: general biochemistry. 2 lectures; 2 credits.

**850. Physical Biochemistry**

The physical chemistry of biological molecules with emphasis on the structure and properties of proteins. Beginning with the physico-chemical properties of water and the amino acids, discussion will proceed to the primary structure, conformation, and interactions of proteins. Included will be a consideration of the theory and applications of physical methods, such as X-ray diffraction, optical rotation, spectra, sedimentation, and light scattering. Mr. Klippenstein. Prerequisite: physical chemistry and general biochemistry. 2 lectures; 2 credits.

**852. Advanced Biochemistry Laboratory**

Application of chemical and physical techniques to the purification and characterization of proteins and nucleic acids. Separation methods including various types of chromatography and electrophoresis will be used. Ultracentrifugation,



spectroscopy, and viscometry will be among the techniques employed to study macromolecular structure. To be taken in conjunction with Biochemistry 850. Mr. Klippenstein. 2 laboratories; 2 credits.

#### 897, 898. Biochemistry Seminar

Presentation and discussion of recent investigations. Mr. Herbst and staff. Prerequisite: permission of the Department Chairman. 0 credit.

#### 899. Master of Science Thesis

To be arranged. 6-10 credits.

#### 999. Doctoral Research

## Biology (41)

Chairman of Graduate Committee: *Langley Wood*

Students whose primary professional goal is to teach biological science in secondary schools have two routes available: The first (MAT) is designed for those who have a strong undergraduate science major but who need training that will lead to certification. This program is administered by the Department of Education with the cooperation of the Biology Committee (chairmen of the Departments of Botany, Entomology, Microbiology, and Zoology).

Applicants with teaching experience and state certification but who need additional training in the biological sciences are eligible for the graduate program leading to the Master of Science for Teachers (MST). This program is administered by the Biology Committee, which shall determine, in light of the student's objectives and deficiencies, courses to be passed by the candidate.

While this program is generally flexible so that it can satisfy the widest possible variety of needs, it is specified that 20 of the necessary 30 credits must be earned in graduate courses offered by biological science departments. In all other respects the requirements for the MST degree conform to the criteria established on page 19 of this catalog.

Inquiries concerning the MST program should be addressed to the Chairman of the Biology Committee.

#### 612. Invertebrate Biology for Science Teachers

A study of available forms, principally insects, which have particular application for use in school science courses, concentrating upon living organisms in field and laboratory. Mr. Schaefer. Prerequisite: two biology courses or permission of instructor. 4 credits.

#### 641. General Ecology

Interrelationships between organisms and their physical environment, population growth, structure, and species interactions; introduction to the ecosystem: energetics, succession, and structure, with intensive study of selected examples. Staff of Botany and Zoology Departments. Prerequisite: One course in biology. 4 credits.

#### 791. Biology-Education. Problems in the Teaching of High School Biology

Objectives and methods of teaching, selection and organization of materials, preparation of visual aids, setting up of aquaria and other projects. The use

of the field trip as a tool in teaching high school biology. Mr. Schaefer. Prerequisite: two years of biological sciences and Principles of Teaching. This course is currently open only to students in the Education "Block Program" for the preparation of secondary school biology teachers. 4 credits.

For listings of other courses see: Botany, Entomology, Microbiology, and Zoology.

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## Botany (27)

Chairmanship Committee: *Richard Schreiber, Arthur Mathieson, Avery Rich*

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PROFESSORS: Stuart Dunn, Albion Hodgdon, Lorne McFadden, Charlotte Nast, Avery Rich, Mathias Richards, Richard Schreiber

ADJUNCT ASSOCIATE PROFESSOR: Alex Shigo

ASSOCIATE PROFESSORS: Thomas Furman, Arthur Mathieson

ASSISTANT PROFESSOR: May Moss

Students admitted to graduate study in Botany are expected to have had adequate preparation in basic botany courses and in the physical sciences. The candidate for the Master of Science degree will be required to defend a thesis based on field or laboratory research. Students who are working toward the Doctor of Philosophy degree may be asked to demonstrate knowledge of one or two foreign languages or a cognate field, such as statistics, as an equivalent. The doctoral candidacy follows a comprehensive examination, and includes the defense of thesis which is to be a substantial contribution to knowledge. The Department's areas for graduate study include: Plant Physiology, Mrs. Moss; Plant Ecology, Mr. Furman; Systematic Botany, Mr. Hodgdon; Phycology-Biological Oceanography, Mr. Mathieson; Plant Pathology, Mr. McFadden, Mr. Pawuk, Mr. Rich, and Mr. Shigo; Plant Morphology and Anatomy; Mycology, Mr. Richards; Cell Biology, Mr. Schreiber and Mrs. Moss.

### 706. Plant Physiology

Structure and properties of cells, tissues, and organs; absorption and movement of water; metabolism; growth and irritability. Botany and Plant Science staff. Prerequisite: Botany 411 or Botany 503 and one year of chemistry. 2 lectures; 2 laboratories; 4 credits.

### 721. Freshwater Phycology

Identification, classification, ecology, and life histories of the major groups of freshwater algae. Periodic field trips will be scheduled throughout the semester. Mr. Mathieson. Prerequisite: Botany 411 or Botany 503. 2 lectures; 2 laboratories; 4 credits. (Alternate years; offered in 1970-71.)

### 722. Marine Phycology

Identification, classification, ecology, and life histories of the major groups of marine algae. Particular emphasis will be placed upon the benthonic, marine algae of New England. Laboratories will include field trips during the later portion of the course. Mr. Mathieson. Prerequisite: Botany 411 or Botany 503. 2 lectures; 2 laboratories; 4 credits.

**723. Marine Algal Ecology**

The distribution, abundance, and growth of marine plants in relation to their environment (chemical, physical, and biological). The students will be expected to attend regular, planned field trips and to conduct an independent research project. Mr. Mathieson. Prerequisite: Botany 722, Zoology 715, or permission of the instructor. 2 lectures; 1 laboratory and field trips; 4 credits. (Alternate years; not offered in 1970-71.)

**732. Cytology**

The structure, physiological behavior, and development of cells. The cellular basis of heredity. Mr. Schreiber. Prerequisite: one year each of the biological sciences and of chemistry. 3 lectures; 1 seminar; 4 credits.

**741. Plant Antecology**

The interaction of the individual plant with its environment, including such factors as earth, air, fire, and water; and the resultant processes of symbiosis, adaptation, and evolution. Mr. Furman. Prerequisite: Botany 706 or permission of instructor. 1 lecture; 1 colloquium; 1 laboratory; 4 credits. (Alternate years; not offered in 1970-71.)

**742. Plant Synecology**

The structure, development, and causes of distribution of plant communities. Methods of analysis and interpretation of field data. Laboratories include field trips on shared-cost basis. Mr. Furman. Prerequisite: Botany 566 (or to be taken concurrently); or Forestry 425. 2 lectures; 1 outdoor laboratory; 4 credits.

**747. Aquatic Higher Plants**

A survey of flowering plants, fern relatives, and Bryophytes found in and about bodies of water in northeastern United States. Extensive field work, preparation techniques, representative collections, herbarium work, lectures, and discussions. Mr. Hodgdon. Prerequisite: Botany 566. 1 lecture; 1 colloquium; 1 half-day laboratory; 4 credits. (Alternate years; offered in 1970-71.)

**751. Plant Pathology**

The nature of disease in plants; the symptomatology, etiology, and classification of plant diseases. Mr. Rich. Prerequisite: Botany 411 or Botany 503, or equivalent. 2 lectures; 2 laboratories; 4 credits.

**752. Mycology**

Studies of the parasitic and saprophytic fungi, their growth, reproduction, and identification. Mr. Richards. 1 lecture; 2 laboratories; 4 credits.

**753. Forest Pathology**

Forest and shade tree diseases; principles, etiology, epidemiology, and control. Mr. Pawuk. Prerequisite: Botany 411 or Botany 503, or equivalent. 2 lectures; 2 laboratories; 4 credits.

**754. Principles of Plant Disease Control**

Exclusion, eradication, protection, and immunization, and the specific practical methods used to control plant diseases. Mr. Rich. Prerequisite: Botany 751 or 753. 1 lecture; 2 laboratories; 4 credits. (Alternate years; not offered in 1970-71.)

## **758. Plant Anatomy**

The anatomy of vascular plants with special emphasis upon tissue development and structure. Prerequisite: Botany 411 or Botany 503. 2 lectures; 2 laboratories; 4 credits.

## **762. Morphology of the Vascular Plants**

The life histories and evolution of the extinct and living vascular plants, including comparisons of general structure and sexual organs. Prerequisite: Botany 411 or Botany 503. 2 lectures; 2 laboratories; 4 credits. (Alternate years; offered in 1970-71.)

## **764. Microtechnique**

A methods course in embedding, sectioning, and staining plant tissues, and an introduction to microscopy. Mrs. Moss. Prerequisite: Botany 411 or Botany 503, permission of instructor. 2 lectures; 4 hours of laboratory; 4 credits.

## **767. Advanced Systematic Botany**

The principles and rules of plant classification and nomenclature; study of plant families, field and herbarium work. Mr. Hodgdon. Prerequisite: Botany 566. 1 lecture; 1 colloquium; 1 laboratory (full afternoon); 4 credits. (Alternate years; not offered in 1970-71.)

## **799. Botany Seminar**

Presentation and discussion of oral reports on research with practice in use of visual aids. Participation by all resident departmental majors. Botany Club in charge. 1 hourly session. 0 credit.

## **805. Advanced Plant Physiology**

Plant physiological phenomena, such as absorption, permeability, mineral nutrition, photosynthesis and light effects, respiration, and growth regulator effects. Prerequisite: Botany 706 or equivalent, or adequate preparation in the physical sciences. Conferences, laboratory, and assigned reading. 3 or 4 credits. (Alternate years; not offered in 1970-71.)

## **822. Advanced Marine Phycology**

Classification, ecology, and life histories of marine algae considered at an advanced level. Seminars, discussions, assigned reading, and laboratory. Mr. Mathieson. Prerequisite: Botany 722 or its equivalent. 4 credits. (Alternate years; not offered in 1970-71.)

## **830. Morphogenesis**

The study of form and development as affected by internal and external factors. Miss Nast. Prerequisite: Botany 758 and 762. 2 recitations of 2 hours each. 4 credits. (Alternate years; not offered in 1970-71.)

## **841. Plant Symbiosis**

The mutualistic relationships between plants and other organisms, resulting in adaptive structures and competitive advantages. Ecology, evolution, and logical bases for the understanding of relationships such as lichens, root nodules, and mycorrhizae. Mr. Furman. Prerequisite: Botany 741. Lectures, laboratory, assigned readings, discussions. 4 credits. (Alternate years; offered in 1970-71.)

**851. Advanced Plant Pathology**

Advanced theories and methods in plant pathology. Mr. McFadden. Prerequisite: Botany 751 or 753 and permission of professor. Assigned reading, conferences, and laboratory. 4 credits. (Alternate years; not offered in 1970-71.)

**861. Plant Geography**

The distribution of plants, a consideration of vegetation types and floras, and problems of endemism with emphasis on North America; the major influential factors such as geologic, climatic, edaphic, and biotic, including man's activities. The major contributions from Humboldt to the present time. Mr. Hodgdon. Prerequisite: permission of professor. 1 lecture; 1 colloquium of 2 hours; field trips; 4 credits. (Alternate years; not offered in 1970-71.)

**895-896. Investigations in (1) Systematic Botany, (2) Plant Physiology, (3) Plant Pathology, (4) Plant Anatomy, (5) Plant Ecology, (6) Mycology, (7) Cytology, (8) Phycology, (9) Botanical Teaching, (10) Morphology, (11) Cell Physiology**

Elective only upon consultation with the botany department chairman and the appropriate professor. Staff hours to be arranged. 2-6 credits.

**899. Master of Science Thesis**

6-10 credits.

**999. Doctoral Dissertation**

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**Business Administration (71)**

*Dean: Jan Clee*

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**PROFESSORS:** John A. Beckett, Carroll M. Degler, Herman Gadon, John J. Korbel, Dwight R. Ladd, Donald C. Marschner, Samuel R. Reid

**ASSOCIATE PROFESSORS:** Allan J. Braff, Jan E. Clee, Stephen L. Fink, James O. Horri-gan, James H. Schulz, Robin D. Willits, Dwayne E. Wrightsman

**ASSISTANT PROFESSORS:** Thomas W. Bolland, Allan R. Cohen, R. Stephen Jenks, Richard L. Mills, John Terninko, William E. Wetzal, Jr.

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**Whittemore School of Business and Economics**

The Whittemore School program leading to the degree of Master of Business Administration is designed to prepare graduates for professional careers in administration in industrial and other organizations in a rapidly changing world. It provides for knowledge and understanding of management principles and practices, through study of (1) the increasing body of relevant knowledge drawn from the behavioral sciences, mathematics, and economics, (2) the existing and emerging processes and institutions of the functional fields of business, and (3) the role of business and other organizations in the complex and ever-changing society.

Candidates for admission must possess a Bachelor's degree from an accredited college or university. In addition, all candidates are expected to take the Admissions Test for Graduate Study in Business (ATGSB) given by the Educational Testing Service. Details concerning times, places, etc., for these examinations may be obtained from Education Testing Service, Box 966, Princeton, N. J. 08540.

The Whittemore School welcomes applicants from any academic discipline, but previous work in mathematics, economics, the behavioral sciences, and the branches of engineering are of particular relevance to graduate study in Business Administration. Because of the increasing use of mathematical concepts, models, and notation in the practice and study of business administration, applicants should normally have successfully completed one year of college mathematics, preferably including an introduction to the calculus.

In all cases, the applicant's entire educational background, relevant experience, references, and professional aims will be considered in the admissions process. Exceptions may be made to any of the foregoing requirements by the Committee on Admissions.

The program leading to the Master of Business Administration degree consists of sixteen four-credit courses and requires two years of full-time study. In the first year of the program separate courses are integrated into an overall study of the nature of business administration in a rapidly changing environment. The first semester, the student will be largely concerned with study of concepts and analytical techniques drawn from the basic disciplines, such as economics, mathematics, psychology, and sociology, which underlie business administration. In the second semester, some work in the behavioral and quantitative areas is continued and courses dealing with the functional areas of business are introduced. In these courses the concepts and techniques developed in the early part of the year are utilized in dealing with specific business problems.

The second year continues the emphasis on overall management by requiring all students to complete the integrating course, Policy Formulation and Administration. Special attention is also given to the changing and increasingly complex external environment in which management functions, by requiring all students to complete the course, Conceptual Foundations of Business. In addition, the student will select the equivalent of four semester courses from among those offered by the Whittemore School and by other colleges of the University. In selecting these courses the student will normally be expected to develop some concentration in one of the several, designated areas. Where the student elects courses offered by other colleges of the University, such selection requires approval of the Dean of the Whittemore School.

### **705. Operations Research**

Mathematical programming, game theory, inventory, queuing, and scheduling problems, dynamic programming. 4 credits.

### **711. Corporations**

The role of the modern corporation in the economy. Emphasis upon structure of the corporation, the corporate system, combinations, and concentration. Mr. Degler. Prerequisite: Economics 402. 4 credits.

### **712. Organizational Change**

Examination of the process of change in organizations. Consideration of change strategies, the role of the change agent, and his relation to the client system. The bases of resistance to change and the problems encountered by internal and external change agents. Readings include theoretical material on influence, attitude change, and organizational change. Mr. Jenks. Prerequisite: permission of instructor. 4 credits.

**713. Interpersonal and Group Dynamics**

Intensive experimental study of the dynamics of small groups through the use of the class itself as a Laboratory Study Group. Students examine their own behavior and its effects on others through use of the Laboratory Training Group (T-group) as the major learning tool. The course develops both conceptual ability and behavioral skill in this area. Prerequisite: permission of instructor. Mr. Jenks. 4 credits.

**717. Advanced Financial Accounting I**

Accounting theory and practice as they contribute to the significance and limitations of the financial statements by which business communicates financial status to interested outsiders. Mr. Horrigan. Prerequisite: permission of instructor. 4 credits.

**718. Cost and Management**

The effective use of cost accounting, cost analysis, and budgeting in planning and controlling operations. Topics considered include analysis of cost behavior, direct and absorption costing, cost-price-volume relationships, distribution costs, transfer pricing, and capital-expenditure analysis. 4 credits.

**719. Control and Information Systems**

The concepts of systems, their use in enterprise management, and the role and influence of on-line control systems; the nature and uses of information in management. The course includes materials intended to familiarize the student with information theory and technology. 4 credits.

**730. Investment Analysis**

An evaluation of capital markets and of analytical techniques useful for security analysis. The following subjects will be covered: securities characteristics, market institutions, yield structures, price-change patterns, intrinsic value analysis, investment timing, and portfolio management. Lectures, outside readings, and security analysis research projects are the main tools of the course. Mr. Horrigan. Prerequisite: some previous work in financial accounting would be extremely helpful. 4 credits.

**741. Transportation**

The wide range of problems surrounding the American transportation system. The basic economic structure of the transportation industries with particular emphasis on competition among the several modes. Such public policy questions as merger of transportation enterprises and cost-benefit analysis of transportation facilities are considered. While principal emphasis in the course is on freight transportation, the problems of passenger transportation, especially in urban areas, are discussed. Limited attention is given to distribution as a specific function of business enterprise. Lectures and discussions of cases. Two or three short papers and a term paper are required. Mr. Ladd. 4 credits.

**751. Advertising and Promotion**

A theory of promotion: how the modern firm acts to obtain maximum efficiency and effectiveness from the use of the major tools of marketing communication (advertising, personal selling, sales promotion, direct-mail merchandising, publicity), as seen from the point of view of the marketing manager. Some emphasis is also placed upon ethical and moral problems. The course is built

upon lectures, classroom discussions, some creative research, and weekly case analyses. Mr. Marschner. 4 credits.

### **752. Marketing Research**

Marketing research as a basis of formulating marketing policies and strategy. Topics include research design, methods of collecting data, planning the investigation, sampling methods, motivation research, advertising research, and consumer research. 4 credits.

### **753. Comparative Marketing (Innovations and Dynamic Aspects of Marketing)**

The problems related to the acceptance of new products, new brands, and new services are becoming more important. The course deals with the diffusion of innovations. Factors governing the speed and ways in which products become accepted in different societies and the related dynamic aspects of competition are treated. Methods are presented for studying loyalty behavior, the acceptance process, the role of innovators, and group influence. International examples are used and emphasis is placed on the implication for marketing policies. Prerequisite: Administration 651, Business Administration 625, or permission of instructor. 4 credits.

### **754. Consumer Behavior**

The consumer-firm relationship studied in terms of concepts drawn from contemporary, social-science findings, particularly small-group studies, as related to present and prospective marketing activities of a business organization. 4 credits.

### **755. Advanced Financial Management**

Financial policy of the firm with emphasis on solutions to complex problems of: cost of capital, leverage, optimal capital structure, capital budgeting, and working capital management. Discussion of abstract models and how they can be modified and applied to concrete situations. Cases may be used. Mr. Wetzel. Prerequisite: permission of instructor. 4 credits.

### **791. Seminar in Organizations**

Investigation by a restricted group of students of specific issues in organization theory and practice. The exact topic will vary from semester to semester as interests develop and opportunities for field study emerge. Mr. Clee. Prerequisite: permission of instructor. 4 credits.

### **801. Quantitative Analysis**

Calculus, difference equations, and matrix algebra with business applications. 4 credits. (Open to full-time Master of Business Administration students only.)

### **802. Quantitative Analysis**

Probability, sampling, inference, regression, econometric models. 4 credits. (Open to full-time Master of Business Administration students only.)

### **803. Human Behavior in Organizations**

To provide students with an understanding of behavioral science concepts and their use in the analysis of interpersonal relationships in organizations and to develop sensitivity to the range of possible human behavior in organizations. 4 credits. (Open to full-time Master of Business Administration students only.)



**804. Management Organization**

Theories of organization and analysis of contemporary forms and structure. Concern is with development of rational management processes in a dynamic society. 4 credits. (Open to full-time Master of Business Administration students only.)

**806. Financial Management**

Concepts and techniques for determining the need for, the acquisition of, and the management of financial resources of the business. 4 credits. (Open to full-time Master of Business Administration students only.)

**807. Economic Environment of Business**

To provide an understanding of national economic activity including output, income, employment, and price levels and to provide familiarity with present knowledge of the determinants of economic growth and fluctuations. 4 credits. (Open to full-time Master of Business Administration students only.)

**808. Marketing**

Identification, development, and retention of markets for the goods and services offered by the firm. Attention is given to the dynamics of demand and to the blending of the marketing mix. 4 credits. (Open to full-time Master of Business Administration students only.)

**810. Production Management**

Concepts and practices in the planning, supervision, and control of activities concerned with manufacturing the goods and services of the firm. 4 credits. (Open to full-time Master of Business Administration students only.)

**811. Conceptual Foundations of Business**

Study of the modern corporation as a partly economic, partly legal, and partly social organization, including examination of widely held views about business and views of businessmen about themselves. 4 credits. (Open to full-time Master of Business Administration students only.)

**812. Business Policy**

A "capstone" course, focused on industries, companies, and other organizations in operation, and studied through case examples, with emphasis on integration of materials covered in prior courses. 4 credits. (Open to full-time Master of Business Administration students only.)

**815-816. Financial Reporting and Economic Analysis for Management**

An integrated view of accounting and economic analysis. Objectives are to provide the student with some general models of the firm for planning and reviewing operations and with a wide assortment of analytical techniques for decision making. 4 credits.

**861. Control and Information Systems**

An exploration of "systems thinking," "the systems approach," "systems analysis," general system theory, information, and "information systems"; application of such concepts to the management process. Insights are generated by use of examples from physical, biological, and societal organizations. 4 credits.

### 895. Special Projects and Independent Study

Projects, research, and reading programs in areas required for concentration. Sixty days' advance approval of the student's plan of study by adviser and by proposed instructor required. Staff. 4 credits.

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## Chemical Engineering (80)

Chairman: *Oswald T. Zimmerman*

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PROFESSOR: Oswald T. Zimmerman

ADJUNCT ASSOCIATE PROFESSOR: Yin-Chau Yen

ASSOCIATE PROFESSOR: Stephen S. T. Fan

ASSISTANT PROFESSORS: David Chittenden, Henry M. Gehrhardt, Charles B. Schriver

To be admitted to graduate study in Chemical Engineering an applicant is expected to have completed a course of study substantially equivalent to that required for the degree of Bachelor of Science in Chemical Engineering in this University. However, students with good undergraduate records but with deficiencies in certain areas may be admitted on condition that they complete specified courses without credit to make up for their deficiencies. An entrance examination covering basic subjects in chemical engineering will be given to all entering graduate students before registration. No one will be admitted as a candidate for a degree until he has passed all portions of the entrance examination.

A candidate for the master's degree in Chemical Engineering must prepare a thesis, for which up to six credits will be allowed, unless he is specifically exempted by the faculty because of previous research experience.

Courses numbered between 600 and 699 may be taken for graduate credit by non-majors only.

Permission of the instructor and consent of the student's adviser are required for enrollment in all Chemical Engineering courses.

### 607. Physical Metallurgy

The nature of metals, emphasizing the quantum mechanical description of the solid state and including atomic structure, bonding, historical development of metal theories, elementary zone or band theory, and X-ray diffraction. The microscopic metal system, thermodynamics of metallurgical processes, defects and dislocations, phase relations of pure metals and alloys, microstructure, and physical and thermal treatment of metals. Study of some nonmetals. 3 lectures; 1 laboratory; 4 credits.

### 608. Chemical Engineering Design

The principles of cost engineering, including estimation of plant investment, working capital, operating costs, labor requirements, payout time, and profitability. Value of money, capitalized costs, simple and compound interest, depreciation, taxes and insurance, labor requirements, overhead, financing of chemical enterprises, design of equipment and plants for minimum cost, plant location, transportation, sales cost, equipment cost, and cost indexes. Each class selects one or more problems involving the complete design of a chemical plant. For each problem, the most desirable process must be determined, the site selected, the equipment and plant designed, calculations made for all costs,

profitability and payout time, and a complete report prepared, including the drawings of equipment and plant layout. 1 lecture; 3 laboratories; 4 credits.

### **701. High Polymers**

Principles and practice of high-polymer manufacture, including industrial polymerization methods and equipment design. Laboratory work includes typical polymerization reactions and the physical and chemical testing of various types of plastics and synthetic fibers. 3 lectures; 1 laboratory; 4 credits.

### **712. Introduction to Nuclear Engineering**

The scientific and engineering development of nuclear reactors, including basic binding-energy physics, nuclear stability, radioactivity, the elements of nuclear-reactor theory, and the engineering problems of heat transfer, fluid flow, materials selection, and shielding. This course is intended for any interested graduate student. 4 credits.

### **713. Nuclear Chemical Technology**

The design, construction, and operation of nuclear process equipment, including reactors and associated chemical processing facilities, and isotope separations plants. The technology of applied radiation chemistry. Intended primarily for graduate students in chemical engineering. 3 credits.

### **752. Process Dynamics**

A basic treatment of process dynamics, including a study of first- and second-order linear processes and their response to step and sinusoidal driving functions. Graphical analysis of the entire control system is included with special emphasis on the optimum design of a stable system. 4 credits.

### **762. Introduction to Optimization**

Optimization techniques applied to functions not described analytically. Search techniques include Fibonacci search, golden-section search, method of steepest ascent, method of contour tangents, and the method of parallel tangents. Stochastic schemes are considered. Advanced techniques for the optimization of objective functions are considered from a qualitative viewpoint. 3 credits.

### **813. Introduction to Fluid Dynamics**

Equations of change for continuous fluids, laminar Newtonian and non-Newtonian flow; ideal fluid flow; boundary layers methods; turbulence. 3 credits.

### **815. Heat Transfer**

Steady-state and transient heat conduction in solids; heat convection; analytic solutions, similarity relations, boundary layer methods; radiation. 3 credits.

### **816. Diffusive Mass Transfer**

Emphasis on the physical aspects of diffusion; theories of diffusion in dilute gases, dense gases, liquids, and solids; surface diffusion; mixing processes. Simultaneous heat and mass transfer. 3 credits.

### **823. Advanced Chemical Engineering Thermodynamics**

A discussion of the multicomponent open system from the engineering viewpoint; the volumetric and phase behavior of pure substances and of multicomponent systems at physical and chemical equilibrium; fugacity and activity; thermal properties of equilibrium, chemically reacting systems; introduction to statistical thermodynamics. 3 credits.

### **832. Advanced Chemical Engineering Kinetics**

Discussion of specialized applied kinetics problems; catalysis; fast reaction and shock tubes; combustion and detonation processes; non-isothermal kinetics; heat and mass transfer in non-equilibrium, chemically reacting systems. 3 credits.

### **852. Advanced Process Dynamics**

An advanced treatment of process dynamics, including higher order processes and nonlinear processes. Special attention is given to representing a complex process by differential equations, linearizing nonlinear elements, and adequately controlling the entire system. 3 credits.

### **890. Literature Report**

Instruction in the use of the library for chemical engineering research. This course will culminate in the preparation of a literature report on a topic of mutual interest to the student and the chemical engineering faculty. 1 credit.

### **895, 896. Graduate Independent Study**

Directed reading or investigation at the advanced level on topics or problems in chemical engineering. 2-4 credits.

### **897, 898. Graduate Seminar**

Discussion on topics of interest to graduate students and staff; reports of research progress; invited lectures by outside speakers. 0 credit.

### **899. Master's Thesis**

Original investigations in chemical engineering. 1-6 credits.

### **999. Doctoral Research**

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## **Chemistry (81)**

**Chairman:** *Alexander R. Amell*

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**PROFESSORS:** Alexander R. Amell, Albert F. Daggett, Helmut Max Haendler, Paul R. Jones, Robert E. Lyle Jr., Frank L. Pilar

**ASSOCIATE PROFESSORS:** Kenneth K. Andersen, David W. Ellis, Gloria G. Lyle, James D. Morrison, Charles W. Owens, Albert K. Sawyer, J. John Uebel, James H. Weber, Charles M. Wheeler Jr.

**ASSISTANT PROFESSORS:** Charles V. Berney, Colin D. Hubbard, John E. Phelps

The Department of Chemistry offers programs leading to three graduate degrees: Doctor of Philosophy, Master of Science, and Master of Science for Teachers. Entering graduate students (except for those desiring the M.S.T. degree) are expected to take proficiency examinations in chemistry to assist in starting the new student's graduate work at the proper level. These examinations will be offered at the beginning of the semester in September and in February.

The faculty of the Chemistry Department feels that the experience of teaching is a valuable part of the training of the graduate student. Therefore, all graduate students who are Doctor of Philosophy or Master of Science candidates will obtain some teaching experience during their tenure.

## Doctor of Philosophy Degree

Admission to this program is based upon superior work in the usual undergraduate courses in inorganic chemistry, analytical chemistry, organic chemistry, and physical chemistry, as well as the normal supporting courses in mathematics and physics. This degree requires the completion of a research problem presented in the form of a thesis.

The Ph.D. candidate will be expected to demonstrate proficiency in reading chemical literature in German and French or Russian. He will also demonstrate to his doctoral committee that he has a broad basic knowledge of the field of chemistry: (1) by completing certain fundamental graduate courses, and (2) by means of a series of examinations in his major field. The principal emphasis of the last two years will be on the research project which will constitute the dissertation. During this time the doctoral candidate will present and defend an original research proposal before his doctoral committee.

## Chemical Physics and Soil and Water Chemistry Options

Doctor of Philosophy candidates in Chemistry may elect to enter the Chemical Physics program, an interdisciplinary program offered jointly with the Department of Physics, or the Soil and Water Chemistry program, an interdisciplinary program offered jointly with the Department of Soil and Water Science. In these options, the doctoral student, with the advice of his guidance committee, elects courses in chemistry and in the related disciplines, and writes his dissertation on a research problem appropriate to interdisciplinary treatment.

## Master of Science Degree

Admission to this program is based upon a superior undergraduate average and requires satisfactory work in the usual undergraduate courses in inorganic chemistry, analytical chemistry, organic chemistry, and physical chemistry, as well as the normal supporting courses in mathematics and physics. This degree requires the completion of a research problem presented in the form of a thesis.

## Master of Science for Teachers Degree

This program is offered for candidates who hold a secondary-school teacher certification in chemistry. Courses leading to this degree will normally be chosen from Summer Session and Summer Institute offerings and require 30 semester hours in courses approved by the Department Chairman. Persons interested in this degree should confer with him.

## Analytical Chemistry

### 762. Instrumental Analysis

A treatment of the theory, instrumentation, and application of methods such as emission spectrography, flame spectrometry, spectrophotometry, gas chromatography, coulometry, potentiometry, conductimetry and polarography to chemical analysis. Mr. Daggett. Prerequisite: Chemistry 406; Chemistry 684 as a prerequisite or concurrently or permission of instructor. 3 lectures; 2 laboratories; 4 credits. Cannot be used for graduate credit by chemistry students.

### 830. Advanced Optical Methods

Techniques of chemical identification and analysis utilizing optical instrumentation from the standpoint of both theory and application. Topics include NMR, ESR, X-ray fluorescence, mass spectrometry, electron beam microprobe. Mr. Ellis. 3 credits.

### 831. Advanced Electrical Methods

Techniques of chemical identification and analysis utilizing electrical instrumentation from the standpoint of both theory and application. Topics include controlled-current coulometry, A-C polarography, chronoamperometry, cyclic voltammetry, controlled potential coulometry. Mr. Daggett. 3 credits.

### 832. Chemical Instrumentation

The basic modules of chemical instrumentation, both electrical and optical. Mr. Ellis. 3 credits.

### 833. Chemical Separations

The use of various separation techniques prior to analysis, and separations as a method of analysis are discussed. The application of statistics to chemical problems of analysis is covered. Mr. Daggett. 3 credits.

## Inorganic Chemistry

### 775. Inorganic Chemistry

The relationship between chemical reactions and modern concepts of inorganic chemistry on a moderate level. The applicability and limitations of the newer ideas. Mr. Haendler, Mr. Weber. Prerequisite: Chemistry 683-684 or permission of instructor. 4 credits. (May not be used for graduate credit by chemistry students.)

### 804. Advanced Inorganic Chemistry

A survey from the modern point of view, with emphasis on theoretical and structural concepts. Mr. Haendler, Mr. Weber. Prerequisite: Chemistry 775 or its equivalent. 3 credits.

### 847. Advanced Inorganic Chemistry

The chemistry of coordination compounds, their ligand field spectra, magnetic properties, and reaction mechanisms. The metal-ligand bond in crystal field and molecular orbital theories. Mr. Weber. Prerequisite: Chemistry 804 or permission of instructor. 3 credits.

### 848. Advanced Inorganic Chemistry

The theory and practice of X-ray diffraction and the determination of crystal structure. Mr. Haendler. Prerequisite: Chemistry 804 or permission of instructor. 3 credits.

## Organic Chemistry

### 755. Advanced Organic Chemistry

An advanced survey of methods of synthesis and determination of structure, including stereochemistry, of complex organic compounds. Structural determination will be based on chemical and spectroscopic properties, emphasis being placed on the solution of assigned problems. The laboratory will be devoted to the synthesis and structural determination of complex organic compounds,

techniques for the separation and determination of purity of unknown compounds, and the identification of these unknowns by spectroscopy and chemical means. 4 credits.

**801. Theoretical Organic Chemistry**

The structural theories of organic chemistry, including valence-bond and molecular orbital theories. Emphasis on stereochemistry, including conformational analysis, and aromaticity. 3 credits.

**802. Theoretical Organic Chemistry**

The mechanistic concepts of organic chemistry, including discussions of theoretical and experimental methods used in the study of reaction mechanisms. 3 credits.

**811. Synthetic Organic Chemistry**

Advanced discussion of heterolytic and homolytic substitution and elimination reactions of the major classes of organic compounds, with emphasis on the synthetic utility of these reactions. Permission of instructor. 3 credits.

**812. Synthetic Organic Chemistry**

Addition, oxidation, and reduction reactions and selected molecular rearrangements, with emphasis on the synthetic applications of these reactions. The synthesis and structure determination of complex organic compounds. Permission of instructor. 3 credits.

**817, 818. Special Topics in Organic Chemistry**

Specialized courses for the advanced student. Topics may include reaction mechanisms, stereochemistry, spectroscopy, molecular biochemistry, steroids, alkaloids, organic sulfur compounds, and nitrogen heterocycles. Mr. Lyle, Mr. Jones, Mrs. Lyle, Mr. Andersen, Mr. Uebel, and Mr. Morrison. 2 or 3 credits.

## Physical Chemistry

**663. Introductory Radiochemical Techniques**

Radiochemical techniques and laboratory practice in the use of apparatus in many fields of science which utilize radio-chemical operations. Mr. Amell or Mr. Owens. Prerequisite: general inorganic chemistry and general physics. 2 lectures; 2 laboratories; 4 credits.

**683-684. Elementary Physical Chemistry**

The properties of gases, liquids, and solids; thermochemistry and thermodynamics; solutions, chemical equilibria, reaction rates, conductance, and electromotive force. Prerequisite: Mathematics 426 and physics. Undergraduates must register for Chemistry 685-686 concurrently. 2 credits.

**685-686. Physical Chemistry Laboratory**

Experimental work illustrating the principles of chemistry. Emphasis is upon the measurement of thermodynamic properties, chemical kinetics, and methods of determining the structure of matter. Prerequisite: Mathematics 426 and physics. Must be taken concurrently with Chemistry 683-684. 2 laboratories; 2 credits.

**776. Advanced Physical Chemistry**

Foundations of quantum theory, elementary quantum mechanics, theory of spectra, statistical thermodynamics. Prerequisite: Chemistry 683-684. 4 credits.

### **805. 806. Advanced Physical Chemistry**

Wave mechanics and quantum chemistry, spectroscopy, molecular structure; statistical thermodynamics, kinetics, and mechanism. Prerequisite: one year of physical chemistry. 3 credits.

### **821. Physical Chemistry — Chemical Kinetics**

The kinetics of homogeneous and heterogeneous reactions in gaseous and liquid systems, including an introduction to very rapid reactions. Mr. Amell, Mr. Owens, or Mr. Hubbard. Prerequisite: one year of physical chemistry. 3 credits.

### **822. Physical Chemistry — Chemical Thermodynamics**

The foundations and interrelationships of the theory of thermodynamics. The methods by which the theoretical principles may be applied to practical problems. Mr. Wheeler. 3 credits.

### **826. Nuclear and Radiochemistry**

Nuclear structure and reactions, particle accelerators, radioactive decay, detection of particles, and the interaction of particles with matter. Application of radiochemistry to chemical systems and research. Mr. Amell or Mr. Owens. 3 credits.

### **827. 828. Theoretical Chemistry I, II**

The modern concepts and mathematical formalism of quantum mechanics with applications to electronic structures of atoms and molecules, spectroscopy, and the solid state. Mr. Pilar. 3 credits.

### **829. Theoretical Chemistry III**

Statistical mechanics with applications to thermodynamics of non-ideal systems, intermolecular forces, and chemical kinetics. Permission of instructor. Mr. Pilar. 3 credits.

## **General Offerings:**

Courses in which all areas of specialization participate.

### **708. Research Techniques**

Lectures and laboratory to show experimental methods and interpretation of results. Topics include gas liquid chromatography, data handling, nuclear magnetic resonance, mass spectrometry, elementary electronics, and X-ray. Staff. 1-3 credits.

### **807. Introduction to Research**

A course to introduce the Doctor of Philosophy student to the planning, experimental methods, and interpretation of a research problem. The student will present and defend an original research proposal before a faculty committee. Must be completed satisfactorily by all doctoral students. Cannot be used for credit by Master of Science candidates. Staff. 2 credits.

### **895. 896. Colloquium in Chemistry**

a. INORGANIC CHEMISTRY, b. ORGANIC CHEMISTRY, c. THEORETICAL ORGANIC CHEMISTRY, d. PHYSICAL CHEMISTRY, e. ANALYTICAL CHEMISTRY. 3 credits. Sections of the course may be taken to a total of 12 credits.

### **897. 898. Seminar**

Presentation and discussion of recent investigations in chemistry. 1 credit.



**899. Thesis — Problems in Chemistry**

Conferences, library, and experimental work in some field of chemistry. Staff. Credits to be arranged.

**999. Doctoral Research****Courses for the Master of Science for Teachers Degree**

The following courses usually are offered only in the Summer Session.

**781. The Teaching of High School Chemistry**

Contemporary subject matter in general chemistry; choice of experiments for laboratory and lecture demonstrations; and presentation and evaluation of teaching methods which are effective in stimulating students. 4 credits.

**782. Modern Inorganic Chemistry for the High School Teacher**

The current concepts on such topics as fundamental particles, atomic structure, nuclear reactions, electronic configurations and orbitals, chemical bonds, the periodic table, oxidation-reduction, acids and bases, energy relationships, and ionic reactions. Prerequisite: freshman chemistry. 4 credits.

**783. Analytical Chemistry for High School Teachers**

The principles of ionic equilibria in qualitative and quantitative analysis. Experimental work in qualitative analysis using the semimicro technique. The experimental work in quantitative analysis acquaints the student with the principles, techniques, and calculations of gravimetric and volumetric determinations. Some experimental work involves the use of the spectrophotometer in quantitative analysis and of the glass electrode method of measurement of pH. 8 credits.

**784. Modern Approach to Organic Chemistry for High School Teachers**

The structure and properties of organic compounds, including those of current interest and importance, such as natural and synthetic polymers, antibiotics, and medicinals. An understanding of the behavior of organic compounds will be based on the current theories of reactions. Prerequisite: general chemistry. 8 credits.

**785. Physical Chemistry for High School Teachers**

The laws of chemistry and their application to physical and chemical changes. Prerequisite: college physics, algebra, and trigonometry. 8 credits.

**786. Radiochemistry for High School Teachers**

The theory of radioactive decay, the effects of radioactive decay upon matter, and the methods and techniques of the detection of radioactive decay. The uses of radiotracers in research. Prerequisite: general chemistry and general physics. 4 credits.

**787. Laboratory Techniques in Chemistry**

Modern methods for the separation, identification, and estimation of substances. Experiments will be designed to assist the teacher by providing new subjects for laboratory demonstrations and student projects. Prerequisite: analytical and organic chemistry. 4 credits.

### 788. Advanced Organic Chemistry for High School Teachers

Types of homolytic and heterolytic reactions of organic compounds and their relationship to organic structures, including configuration and conformation. Prerequisite: Chemistry 794 or its equivalent. 4 credits.

### 789. Atomic and Molecular Structure

The methods of determining atomic and molecular structure, including ultra-violet and infrared spectroscopy and radiochemistry. 4 credits.

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## Civil Engineering (82)

Acting Chairman: *Louis H. Klotz*

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PROFESSOR: J. Harold Zoller

ASSOCIATE PROFESSORS: Louis H. Klotz, Harold E. Langley Jr., John P. Neilson, Tung Ming Wang

A candidate for the degree of Master of Science in Civil Engineering must have completed a Baccalaureate degree in engineering, mathematics, or science. If his undergraduate work is deficient, he may be required to take undergraduate courses without graduate credit in order to present the proper prerequisites for graduate courses in the areas of his major and minor interests. In addition, other undergraduate courses may be required by his adviser in order to achieve an integrated program. The candidate for the Master's degree will normally complete a thesis for six hours of credit (a maximum of nine hours credit may be awarded in unusual cases). With the permission of the department, a student may be permitted to substitute approved course work for the thesis requirement. In this event he must also submit to his examining committee a paper written in one of his courses which is the equivalent of a thesis in style and quality, but not in scope. One copy of the thesis or paper is required by the department. An oral final examination is required of all candidates.

Courses numbered above 700 may be offered biennially or upon demand.

### 701. Advanced Surveying

Principles of instrumental and analytical photogrammetry. Theory of conformal mapping and the application to the State Plane Coordinate Systems. Geodetic surveying. Error theory and its application to the planning and adjustment of surveys. Application of electronic computers to surveying calculations. 3 lectures; 1 laboratory; 4 credits.

### 711. Community Planning

An introduction to Community Planning. Social, economic, and physical factors affecting community planning; content and extent of desirable community-planning programs, including purpose and scope; preliminary survey; elements of land planning; the master plan; transportation and circulation systems; street patterns and traffic; motor vehicle parking; airport sites; public building sites; parks and recreational facilities; zoning; control of land subdivision; neighborhood and shopping centers; housing, legal, financial, and economic problems; and redevelopment of blighted areas. Mr. Dawson. Prerequisite: permission of the instructor. 4 lectures; 4 credits.

**714. Contracts, Specifications, and Professional Relations**

The essential elements and legal requirements of engineering contracts; the purposes and content of specifications; professional conduct, relations, registration, and ethics. Construction planning and management; cost analysis based on quantity surveys and unit-cost methods. Mr. Dawson. Prerequisite: permission of the instructor. 4 lectures; 4 credits.

**721. Highway Engineering II**

Design of flexible and rigid pavements and bases for highways, airports, and city streets; pavement selection, construction methods, materials, specifications, and engineering cost estimates. 3 lectures; 1 laboratory; 4 credits.

**731. Network Planning and Scheduling**

The application of Critical Path Methods (CPM) and Project Evaluation Review Technique (PERT) to the design and control of civil engineering projects. 1 lecture; 1 laboratory; 2 credits.

**732. Systems Analysis**

An analysis of civil engineering projects encompassing social and economic criteria as well as engineering feasibility studies. 1 lecture; 1 laboratory; 2 credits.

**744. Sanitary Engineering II**

An advanced treatment of water supply and waste water disposal. 4 lectures; 4 credits.

**745. Hydrology and Hydraulics**

The occurrence and physical effects of water on the earth, including meteorology, ground-water runoff, and stream-flow routing, open channel flow, reservoirs, control works, hydroelectric power, irrigation, drainage, and multipurpose projects. 4 lectures; 4 credits.

**765. Applied Soil Mechanics**

Application of the principles of soil mechanics to selection of the type of substructure; determination of allowable soil bearing capacities based on rupture and settlement theories; determination of active and passive earth pressures; and foundation construction methods. Computations by classical, numerical, and computer applied methods. 4 lectures; 4 credits.

**782. Timber Design**

Properties and characteristics of structural woods, mechanics of wood, connection methods, design of timber members and connections in beams, columns, and trusses, and glued laminates of wood. Prerequisite: Civil Engineering 682 and permission of the instructor. 1 lecture; 1 design period; 2 credits.

**784. Introduction to Matrix and Numerical Methods**

Presentation of a unifying concept of basic structural-analysis theories; introduction to matrix and numerical methods of analysis and their application by linear graph concepts using computers. 3 lectures; 1 design period; 4 credits.

**790. Inelastic Structural Design**

A continuation of modern design theory, ultimate design of reinforced concrete, and plastic analysis of steel structures. 4 lectures; 4 credits.

### **793-794. Advanced Structural Design I and II**

The design in steel by the elastic theory and in reinforced concrete by the working stress method of structural elements and connections, using the appropriate controlling specifications. 3 lectures; 1 design period; 4 credits.

### **795-796. Independent Study**

A limited number of qualified senior and graduate students will be permitted to pursue independent studies under faculty guidance. Seniors may write terminal theses reporting the results of their investigation. 2-4 credits.

### **822. Highway and Airport Engineering**

Design of flexible and rigid pavements and bases for highways, airports, and city streets; pavement selection, construction methods, materials, specifications, and engineering cost estimates. Prerequisite: Civil Engineering 620 and 665. 2 lectures; 2 laboratories; 4 credits.

### **855-856. Advanced Sanitary Engineering**

The application of Chemistry and Microbiology in Sanitary Engineering. The study of control and treatment systems for industrial waste. 4 lectures; 4 credits.

### **863-864. Advanced Soil Mechanics I and II**

The physical and mechanical properties of soil in relation to engineering structures. The theory of consolidation, shearing resistance, bearing capacity, settlement, slope stability, earth pressure, and seepage studies. 4 lectures; 4 credits.

### **865. Soils Engineering**

Application of soil mechanics' principles to the selection of the type of substructure and the development of its bearing capacity, based on the theories of stability analysis and consolidation. Earth-pressure load determinations by various active and passive earth-pressure theories. Earth dam and foundation construction methods. 4 lectures; 4 credits.

### **866. Soil Testing for Engineering Purposes**

The essential tests for the physical properties: permeability, capillarity, compressibility, rate and magnitude of consolidation, and shearing resistance. 2-4 credits.

### **881. Advanced Structural Analysis I**

Advanced structural theory and analysis, including multi-story structures, beam columns, frames with variable moment of inertia, continuous trusses and bents, arches and curved frames, stiff rings, and closed frames. 4 lectures; 4 credits.

### **882. Advanced Structural Analysis II**

Advanced treatment, including flexible and axially loaded flexural members, beams with variable cross-section subjected to axial loads, suspension bridges and flexible arches, and torsional problems of noncircular sections. 4 lectures; 4 credits.

### **883. Structural Stability**

Study of the elastic and inelastic buckling behavior of structures. Topics include: stability of columns, mathematical treatment of buckling problems and buckling criteria, lateral stability of beams, buckling of trusses and framed structures, and stability of rings and curved beams. 4 lectures; 4 credits.

**884. Dynamics of Structures**

Analysis of structures subjected to dynamic loadings. Free and forced vibrations with one or multi-degrees of freedom. Effects of damping and inelastic action. Vibrations of beams and framed structures. Dynamic response of beams due to moving loads. 4 lectures; 4 credits.

**885. Application of System Theory to Structural Analysis**

Comprehensive development of the stiffness matrix of structures. Intuitive concepts of topology and linear graphs and their application to structural frameworks. Analysis of structures using linear graphs. 4 lectures; 4 credits.

**886. Facility Project Engineering**

A critical review of the approaches to the planning and decision processes of facilities, including: codes and specifications, concepts of engineering economy, index numbers and cost estimation procedures (including an introduction to their statistical basis), mathematical modeling concepts, and the development of design loads and criteria for specific application. 4 lectures; 4 credits.

**887. Application of Linear Graphs to Civil Engineering**

Concepts of topology and linear graphs and their application to civil engineering planning of transportation, water and sewage distribution, and other networks. Network planning and management systems, including Project Evaluation Review Technique (PERT), Critical Path Methods (CPM), and PERT/cost procedures. 4 lectures; 4 credits.

**890. Topics in Structures**

Studies of topics of special interest and need of the student in structural design, analysis, and optimization. 2-4 credits.

**895-896. Civil Engineering Problems**

The study and investigations of problems selected to meet the needs of the students. 2-8 credits.

**899. Master's Thesis**

Hours and credits, 6-9; to be arranged.

**Economics (72)**

Dean: *Jan E. Clee*

PROFESSORS: Robert F. Barlow, Carroll M. Degler, John A. Hogan, Manley R. Irwin, John J. Korbel, Samuel R. Reid, Sam Rosen, Kenneth J. Rothwell

ASSOCIATE PROFESSORS: George W. Betz, Allan J. Braff, Jan E. Clee, James H. Schulz, Dwayne E. Wrightsman

ASSISTANT PROFESSORS: Lawrence R. Cole, John V. Donovan, William R. Hosek, Richard L. Mills, Robert C. Puth

**Whittemore School of Business and Economics**

Admission to graduate study in Economics leading to the degree of Master of Arts is limited to students with a better than average undergraduate record. Candidates for admission are required to take the Graduate Record Examination (both the Aptitude Test and Advanced Test in Economics). The prerequisite for graduate

work consists of a minimum of 24 hours of undergraduate study in Economics and related fields of which at least 12 hours shall have been in Economics. In addition, all candidates must either present six hours of undergraduate credit in statistics or mathematics, or take six hours of undergraduate work in statistics or mathematics at the University of New Hampshire without credit, or pass a proficiency test in either field.

The candidate for a Master's degree must fulfill the general requirements of the Graduate School and the following major requirements: (1) Thirty semester hours of graduate study or 24 semester hours and a thesis: (a) a minimum of 21 semester hours in courses numbered 700 and above, of which 6 hours may be satisfied by an acceptable thesis; at least 9 of these hours, exclusive of the thesis, must be in courses numbered 800 and above; (If a thesis is to be submitted, it must be in form for presentation to the Reading Committee by May 1 of the year in which the degree is to be granted.) (b) a maximum of 9 semester hours in approved courses numbered 600 and above in related disciplines. (2) A course grade of P or better at the graduate level as evidence of proficiency in both micro- and macro-economic analysis. (3) Evidence of proficiency, based upon a written examination, in one of the following major areas: (a) Quantitative Methods (b) Labor Economics and Industrial Relations (c) Public Policy Toward Business and Labor (d) Economic Growth and Stability (e) International Economy and Economic Development (f) Resource Development (g) Economic History and the History of Economic Thought.

### **711. Economic Fluctuations**

The study of recurrent movements of prosperity and depression, with emphasis upon causes and public implications. Prerequisite: permission of instructor. 4 credits.

### **720. U. S. Economic History**

The development of the United States economy from Colonial times to the present. Presentation and application of economic models and interpretation of data are stressed. The influence of capital accumulation, industrialization, foreign trade, monetary factors, and government are considered, with peripheral attention to non-economic factors. Primarily a course in applied economic theory. 4 credits.

### **721. European Economic History**

The development of Western European and Mediterranean economics from medieval times to the common market. Presentation and application of economic models and interpretation of data are stressed. Attention is centered on capital accumulation, technology, trade, industrialization, monetary factors, and the role of government, but the influence of non-economic factors is discussed where relevant. 4 credits.

### **725. Statistical Theory**

The theoretical basis of statistical methods, probability, probability distributions, statistical inference, and decisions. Prerequisite: permission of instructor. 4 credits.

### **726. Mathematical Economics**

An introduction to the principal mathematical techniques and their application in economics. Prerequisite: permission of instructor. 4 credits.

**727. Introduction to Econometrics**

The application of statistics and mathematics to economic problems. The formulation of economic models, their measurement, and verification. Prerequisite: permission of instructor. 4 credits.

**728. Statistical Decision Making**

The application of probability and statistics to decision problems. Special emphasis on the Bayesian approach to decisions under uncertainty. Prerequisite: permission of instructor. 4 credits.

**735. Advanced Money and Banking**

Emphasis on central banking, monetary policy, and monetary theory. Study of current problems and developments in banking. 4 credits.

**750. Imperfect Competition**

Extensive survey of firm behavior in imperfectly competitive market forms, such as monopoly and oligopoly. The implications for price and research performance under such market forms are examined and the relevance of the theoretical arguments are assessed by recourse to appropriate empirical studies. Prerequisite: Economics 673 or 605 or permission of instructor. 4 credits.

**757. Public Policy in Social and Labor Legislation**

American social and labor legislation of the recent decades and the way in which American economic and human values have been implemented and modified by law. Legislation and private industry programs in social security, reemployment, unemployment insurances, health services, training and retraining, and fair employment practice. Lectures, discussion, assigned reading, and individual student projects. Prerequisite: one year's work in economics or sociology. 4 credits.

**851. Human Relations in Industry**

Labor-management relations studied as one aspect of human relations; applications of recent research in the behavioral sciences; case studies. Mr. Hogan. 4 credits.

**852. Economics of Collective Bargaining**

Tools of economic analysis applied to collective bargaining—wages, productivity, seniority rules, job security, package bargaining. Application to cases. Mr. Hogan. 4 credits.

**857-858. History of Economic Thought**

The evolution of economic thought. Examination and critical appraisal of the work of major economists and major schools of economists. Mr. Hosek. 4 credits.

**859. Government Regulation of Business**

Analysis of government policy with reference to such problems as conspiracy, monopoly, mergers, unfair practices, and discrimination. This analysis includes a legal and economic appraisal of government policy alternatives. Mr. Irwin. 4 credits.

**861. National Economic Planning**

Analysis of the functioning of various types of national economic systems. Emphasis on economic planning and development. Mr. Donovan. 4 credits.

## Education

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### 863. International Economics

Contemporary issues in international economic theory and policy. Analysis of trade theory, balance of payments problems, international liquidity, and the adjustment processes. Mr. Rothwell. 4 credits.

### 873. Macro-economic Theory

Advanced analysis of such aggregates as national income, total output, employment, and the general price level. Examination of the major aggregate models. Mr. Rosen. 4 credits.

### 878. Micro-economic Theory

Topics in micro-economics with emphasis on recent developments in such areas as general equilibrium analysis, welfare economics, demand theory, and capital theory. Mr. Braff. 4 credits.

### 891. Seminar in Monetary Theory and Policy

Contemporary developments in monetary theory and the evaluation of policy measures. Mr. Wrightsman. 4 credits.

### 892. Seminar in Public Finance — Theory and Policy

Selected topics in contemporary theoretical and policy problems of public finance. Mr. Schulz. 4 credits.

### 894. Seminar in Economic Development

A survey of theories and detailed case studies in problems of economic development. 4 credits.

### 895-896. Independent Study

Selected projects. Staff. 8 credits.

### 899. Thesis

Staff. 8 credits.

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## Education (48)

Chairman: *Roland B. Kimball*

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PROFESSORS: Roland B. Kimball, Thomas O. Marshall, Carleton P. Menge, Angelo V. Boy

ADJUNCT PROFESSOR: Walter N. Durost

ASSOCIATE PROFESSORS: John G. Chaltas, David D. Draves, Edward D. Durnall, Bud B. Khleif, Joseph J. Petroski, Gerald J. Pine, M. Daniel Smith

ASSISTANT PROFESSORS: Michael D. Andrew, Charles H. Ashley, Gilbert R. Austin, Jason E. Boynton, John R. Cavanaugh, Ronald P. Curcio, Albert R. Elwell, Hubert A. Hardy, David D. Hebert, Judith A. Meagher, James W. Mittelstadt, Philip E. Northway, Philip M. Smith, Deborah E. Stone, W. Dwight Webb

### Admission to Graduate Standing

Admission to graduate standing in the Department of Education is granted to applicants meeting the entrance requirements of the Graduate School and accepted by the Department. Applications must include Graduate Record Examination scores for both the aptitude test and the achievement test in the field selected by the applicant.



The Department offers courses leading to the Master of Education degree and to the Master of Arts in Teaching degree.

### Master of Education

Master of Education programs are offered in the following areas of specialization:

Elementary Education	Reading
Secondary Education	Administration and Supervision
Counseling and Personnel Services	School Library Science

Applicants should indicate their anticipated area of specialization on their admissions application form.

Specific requirements for completion of the programs vary with the area of specialization. For further information, write to the Chairman, Department of Education.

### Thesis or Comprehensive Examination

Candidates in the Master of Education program ordinarily will be expected to complete a research thesis, or a comprehensive examination, which may be written or oral. Each candidate will plan this portion of his program in terms of his own professional needs and in consultation with his graduate adviser. There is no thesis or examination requirement for the Master of Arts in Teaching.

### Master of Arts in Teaching—Elementary and Secondary Programs

The Master of Arts in Teaching program is designed for candidates who have completed an undergraduate degree with a strong academic major but have not followed a program of professional preparation for teaching. The Elementary Program is open also to relatively inexperienced, uncertified teachers. The Master of Arts in Teaching program will provide a balanced curriculum in teacher preparation, with strong emphasis on a supervised internship in teaching and an opportunity to complete further graduate work in the academic subjects most closely related to the candidate's teaching field.

Candidates will spend two summers and the intervening academic year in graduate study. The first summer will provide an opportunity to study and practice educational methods under the supervision of master teachers in a local summer high school and summer elementary school. During the academic year the student will be placed in a local school system as a teaching intern with a half-time load. Interns may be paid by the local school system, according to the policy of the local school board. Concurrently the intern will attend seminars on campus which extend his grasp of educational theory and method and will relate these studies to the experiences the intern encounters as a teacher in a school system. The final summer will complete the courses included in the program.

The Master of Arts in Teaching programs are open to prospective elementary school teachers and prospective secondary school teachers of English, mathematics, the sciences, social studies, and foreign languages. For further information, prospective elementary school teachers should write to Mr. John Chaltas, Coordinator, M.A.T. (Elementary), Department of Education. Prospective secondary school teachers should write to Mr. Philip Smith, Coordinator, M.A.T. (Secondary), Department of Education.

### Certificate of Advanced Graduate Study

There is a post-master's degree in counselor education leading to a Certificate of Advanced Graduate Study. For further information, write to Professor Angelo V. Boy, Department of Education.

#### 734. Children's Literature

A consideration of children's books and methods of using them, with emphasis given to intermediate grades. Practical demonstrations of how to correlate children's books with various special subjects. 4 credits.

#### 763. Instructional Media

Introduction to instructional media and technology. Emphasis is given to theory, design, and application of instructional media systems. Prerequisite: Education 657. 4 credits.

#### 764. School Library Materials and Services

The background and development of the school library, including functions, objectives, and standards. The relationship of library services to the curriculum, classroom teacher, and students, and to the public library. 4 credits.

#### 765. Reference Materials in the School Library I

The selection and evaluation of basic reference materials common to all libraries. An introduction to school library informational and research techniques. 4 credits.

#### 766. Technical Processes in the School Library I

Ordering, processing, and organizing school library materials. Special emphasis on classification and cataloguing systems. 4 credits.

#### 767. Materials Selection for School Libraries

Techniques for building the school library collection in all subjects. Analysis of books for children and young people. Practice in compilation of bibliographies for selected levels and interests. Prerequisite: Education 764 and 765. 4 credits.

#### 785. Educational Tests and Measurements

An introduction to the theory and practice of educational evaluation. Emphasis is given to uses of test results in classroom teaching and student counseling. Introductory statistical techniques. Prerequisite: Education 657. 4 credits.

#### 800. Curriculum and Method in Elementary School Social Studies

An analysis of research studies, current curriculum proposals, and instructional strategies in the field of elementary-school social studies. Prerequisite: Education 611 and teaching experience. 4 credits.

#### 801. Curriculum and Method in Elementary School Mathematics

An analysis of research studies, current curriculum proposals, and instructional strategies in the field of elementary school mathematics. Prerequisite: Education 612 and teaching experience. 4 credits.

#### 802. Curriculum and Method in Elementary School Science

An analysis of research studies, current curriculum proposals, and instructional strategies in the field of elementary-school science. Emphasis will be given to

a consideration of contemporary equipment and materials for science education. Prerequisite: Education 613 and teaching experience. 4 credits.

**806. Language and Literature in the Elementary School**

A study of language and literature in the elementary school including contributions of allied disciplines such as semantics and linguistics. Focus is on the processes of communication and application to elementary school curriculum. Introduction to bibliotherapy. Prerequisite: Education 610. 4 credits.

**807. Survey of Reading**

An investigation of the research in reading and reading instruction. Emphasis is on the individual learner, the reading process, and the process of learning to read. Comparison of current diagnostic, developmental, and evaluative methods and materials. Prerequisite: Education 614. 4 credits.

**808. Diagnostic and Remedial Reading**

Investigations of the nature and causes of reading disability. Study of diagnostic and remedial procedures and materials through case studies, discussions, demonstrations, and practice. Prerequisite: Education 785 and 807. 4 credits.

**809. Practicum in Developmental and Remedial Reading and Language**

Individual and small group work with children will provide opportunities for clinical analysis, micro-teaching, and evaluation. Seminars will focus on the processes of reading and language and the effects of a variety of methods and materials on learning. Prerequisite: Education 808 (may be taken concurrently) and permission of instructor at least one month before beginning the course. 4 credits.

**810. Reading and Study in the Secondary School**

The nature of the reading process, diagnostic and developmental methods and materials, study skills, and reading in the content areas at the secondary school level. Designed for secondary school teachers who wish to foster continuous development of students' reading and study skills. Prerequisite: secondary school teaching experience. 4 credits.

**820. Counseling Theory and Practice**

The basic approaches to counseling are examined. Consideration is given to their theoretical foundations. Implications for practices in personnel services are emphasized. 4 credits.

**821. Psychology of Vocational Development**

An investigation of the psychological and informational factors which influence occupational decisions and progress. 4 credits.

**822. Psychological Tests in Personnel Services**

An analysis of evaluative instruments and techniques which have particular utility in personnel services. Comparisons of sample instruments in terms of psychological or factorial meanings and predictive uses. Prerequisite: Education 785. 4 credits.

**823. Group Counseling**

An analysis of group dynamics as they apply in group situations relevant to personnel services. Prerequisite: Education 820. 4 credits.

## Education

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### **824. Counseling and Guidance in the Elementary School**

Principles and procedures of counseling and personnel services for meeting the developmental needs of elementary school pupils. Prerequisite: Education 820. 4 credits.

### **825. Laboratory in Counseling**

Supervised application of counseling through involvement in simulated counseling situations in a laboratory setting. Prerequisite: Education 820. 4 credits.

### **826. Practicum in Counseling**

Supervised experiences in counseling with actual clients in the usual organizational settings. Prerequisite: permission of the instructor. 4 credits.

### **827. Organization and Administration of Personnel Services**

An investigation of the organizational patterns and administrative procedures which influence the effectiveness of personnel services programs. Emphasis is on the elements of productive supervisory and staff relationships. Prerequisite: permission of the instructor. 4 credits.

### **828. Advanced Counseling Theory and Practice**

A detailed analysis of the counseling relationship: its characteristics, processes, and outcomes. Prerequisite: permission of the instructor. 4 credits.

### **829. Advanced Practicum in Counseling**

Supervised application of advanced counseling theory and practice in actual counseling situations. Samplings of counseling practices will be analyzed and evaluated. Prerequisite: Education 828 and permission of instructor. 4 credits.

### **830. Research in Personnel Services**

A study of research design and methodology in personnel services. Prerequisite: permission of the instructor. 4 credits.

### **831. Seminar and Practicum for Master of Arts in Teaching (Elementary School)**

Observation of reading and elementary-mathematics master teachers assigned to the University Summer Elementary School. Opportunities to teach elementary school children under supervision. Related seminars in methods of teaching reading and elementary mathematics. (Summer Session only). Prerequisite: admission to the Master of Arts in Teaching Program. 4 credits.

### **832. Internship and Seminar for Master of Arts in Teaching (Elementary School)**

Internship and related seminars as follows: (a) The elementary school curriculum and methods of instruction in elementary school science, social science, music, art, and physical education will be directly related to planning instruction offered by the student as an intern teacher. (b) Half-time elementary school teaching under the supervision of the University faculty. (First semester only.) Prerequisite: Education 831. 6 credits.

### **833. Internship and Seminar for Master of Arts in Teaching (Elementary School)**

Internship and related seminars as follows: (a) A continuation of the seminar started in Education 832. (b) Internship. Half-time elementary school teaching

under the supervision of the University faculty. (Second semester only.) Prerequisite: Education 832. 6 credits.

**835. Seminar and Practicum for Master of Arts in Teaching**  
(Secondary School)

Practicum and related seminars as follows: (a) The secondary school curriculum and general methods of instruction. Candidates will make a detailed study of the secondary school curriculum and special methods of instruction in their own specific teaching field. (b) Candidates are assigned to a master teacher in their specific teaching field for observation in the University Summer High School. There will be opportunities for candidates to do supervised teaching in their subject field. (Summer Session only.) Prerequisite: admission to the Master of Arts in Teaching Program. 6 credits.

**836. Internship and Seminar for Master of Arts in Teaching**  
(Secondary School)

Internship and related seminars as follows: (a) A continuation of the special methods seminar started in Education 835. Candidates elect the seminar which provides a detailed study of the secondary school curriculum and special methods of instruction in their own specific teaching field. The seminar will be directly related to planning instruction offered by the candidate as an intern teacher. (b) Half-time secondary school teaching in the candidate's major field under the supervision of the University faculty. (First semester only.) Prerequisite: Education 835. 4 credits.

**837. Internship and Seminar for Master of Arts in Teaching**  
(Secondary School)

Half-time secondary school teaching in the candidate's major field under the supervision of the University faculty. (Second semester only.) Prerequisite: Education 836. 4 credits.

**838. Sociology of Education: Social Organization of Schools and Community**  
Schools are viewed in their socio-cultural context. Work is centered on a number of field studies of urban and suburban communities. Among the topics discussed are the following: (a) Comparative institutional analysis—what is church-like, hospital-like, factory-like, and prison-like about the school; (b) relations and perspectives of functionaries and clients in “culturally deprived” and “culturally endowed” settings; and (c) teaching as an emergent profession. 4 credits.

**840. Administration of Library-Media Centers**

The planning, organizing, and supervising of library-media centers to support the instructional needs of schools. Prerequisite: Education 766 and 767. 4 credits.

**841. Reference Materials in the School Library II**

Analysis of school-library reference services, materials, and techniques. Prerequisite: Education 765. 4 credits.

**842. Technical Processes in the School Library**

Ordering, processing, and organizing school library materials. Opportunities for practice in technical management of books, pamphlets, periodicals, tapes, recordings, pictures, and other educational media. Prerequisite: Education 766. 4 credits.

**848. Directed Research in School Librarianship**

Prerequisite: Education 764, 767, and 841. 4 credits.

**853. Seminar in Curriculum Study**

The techniques and procedures of curriculum development and strategies for curriculum change in the public schools. Prerequisite: teaching experience. 4 credits.

**858. Analysis of Teaching**

A comparative analysis of current techniques and instrumentation for studying the process of teaching in the classroom. Consideration of substantive and procedural issues involved in planning for teaching. Prerequisite: teaching experience. 4 credits.

**861. Public School Administration**

An introductory course examining major issues in policy-making, school management, personnel, public relations, finance, and research in school administration. Prerequisite: teaching experience. 4 credits.

**862. Educational Finance and Business Management**

Principles of financing education, budgetary procedures, accounting, auditing, school indebtedness, financial reporting and business management. Experience in handling practical school finance problems will be part of the project work. Prerequisite: Education 861. 4 credits.

**863. Seminar in Educational Administration**

Cases and concepts in educational administration. Prerequisite: Education 861. 4 credits.

**865. Educational Supervision**

Theoretical foundations of supervisory behavior as a means of effecting changes in instructional practices; consideration of instruments and techniques based on those theoretical foundations; some opportunity for field projects utilizing instruments and techniques. Prerequisite: teaching experience. 4 credits.

**867. Legal Aspects of School Administration**

Emphasis is on federal and state laws which establish the duties, privileges, and responsibilities of school board members, superintendents, and teachers. The legal aspects of school district organization, negotiation procedures and personnel policies, fiscal operations, school building construction, compulsory attendance, pupil transportation services, and the current legal issues involved in state and federal aid to education. Prerequisite: Education 861 and 863. 4 credits.

**869. Practicum in Educational Administration**

Supervised practical experience in dealing with problems in educational administration. Prerequisite: Education 863. 4 credits.

**881. Methods and Techniques of Educational Research**

Quantitative methods employed in the investigation of educational problems. Permission of instructor. 4 credits.

**883. Advanced Psychology of Human Learning**

Special topics in the field of educational psychology with emphasis on the learning process: (a) examination of learning situations in the classroom in

the light of experimental research; (b) examination and evaluation of learning situations in the light of the major theories of learning. Prerequisite: Education 657. 4 credits.

**884. Advanced Human Development**

A personal exploration of the social, psychological, and educational aspects of human development. Special emphasis on emotional growth through school practices in human encounter. Prerequisite: Education 481, Education 657, or General Psychology. 4 credits.

**886. Philosophy of Education**

A comparative analysis of contemporary educational objectives and practices and the philosophical foundations upon which they are based. Prerequisite: Education 657 and 659. 4 credits.

**888. Sociology of Education: The Cultures of Poverty and Affluence**

The two cultures are treated as a unit; culture change is discussed. Issues of current interest are explored, e.g., poverty, school desegregation, the schooling of geographically mobile children, problems of social mobility and abundance, the rise of the counseling and healing trades, and teachers' quest for professionalism. The education of "culturally deprived" and "culturally endowed" children receives special attention. A comparative approach is adopted; issues are examined cross-culturally and in relation to the schooling process. 4 credits.

**895. Independent Study in Education**

An opportunity for intensive investigation of a special problem or issue in the field of education. Permission of instructor is required. 2-4 credits per semester. May be repeated to a maximum of 8 credits.

**897. Seminar in Contemporary Educational Problems**

A seminar offered by one or more members of the staff dealing with issues or problems of special contemporary significance. Normally the seminar will focus on a problem which has been the subject of recent special study by the staff member(s). Prerequisite: permission of the instructor(s). 4 credits. May be repeated for different topics.

**899. Thesis**

Prerequisite: permission of the department. 4-8 credits.

### Electrical Engineering (83)

Chairman: *Joseph B. Murdoch*

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PROFESSORS: Fletcher A. Blanchard, Albert D. Frost, John B. Hraba, Joseph B. Murdoch, Alden L. Winn

ASSOCIATE PROFESSORS: Ronald R. Clark, Donald W. Melvin, H. Richard Skutt, Kerwin C. Stotz

ASSISTANT PROFESSORS: Glen C. Gerhard, Filson H. Glanz, John L. Pokoski, S. Pyati, K. Sivaprasad, H. F. Wocholz

GRADUATE COORDINATOR: H. Richard Skutt

To be admitted to graduate study in Electrical Engineering a student should have completed work in his major field equivalent to that currently required of undergraduates at the University of New Hampshire.

A minimum of 30 credits is required for the Master of Science degree in Electrical Engineering. All students are required to complete two basic courses, Electrical Engineering 701 and 811, at the beginning of their program, or furnish evidence of equivalent preparation. Students are further required to demonstrate the ability to do independent and creative work by taking either Electrical Engineering 899 or 891-892. With the consent of the Graduate Committee, a student who has satisfied this requirement through industrial experience may substitute approved course work.

Electrical Engineering 899 and 891-892 both involve equivalent independent theoretical and/or applied work under the guidance of a faculty member. The sequence 891-892 is to be completed in two consecutive semesters, with a letter grade given at the end of each semester. An interim report is submitted at the end of 891 and a final (oral and written) report at the end of 892. Electrical Engineering 899 requirements include the submission of a formal thesis suitable for binding. However, no two-semester time limit is imposed, and no interim or final letter grade is given. Those who intend to undertake graduate work in Electrical Engineering must consult with the department graduate adviser in order to plan their program of study, since all courses are not given each year. Normally, a minimum of 12 credits of 800 level courses is required.

Permission of the instructor is required for enrollment in all Electrical Engineering graduate courses.

#### 620. Electronics and Instrumentation

A service course for those students not in engineering or physics. No attempt is made to cover the topics in mathematical or engineering detail. Emphasis is placed on making the student aware of problems which he is likely to encounter when using electronic equipment. Proper technique for using electronic instruments is pointed out in classroom demonstrations and laboratory experiments. Topics covered include D.C. and A.C. circuits, electronic amplifiers, grounding and shielding problems, transducers, electronic instruments, schematic reading, transients, noise problems, and digital techniques. 3 recitations; 1 laboratory; 4 credits.

#### 701. Applied Electromagnetic Fields

Introduction to Maxwell's equations; boundary value problems in electrostatics and magnetostatics; plane wave propagation; reflection and refraction in iso-



tropic media; guided wave propagation; rectangular and cylindrical wave guides; simple resonators; elements of microwave circuits, linear antennas; aperture antennas, arrays of dipoles; directivity receiving antennas and reciprocity. Prerequisite: Electrical Engineering 509, Electromagnetic Fields or equivalent. 3 recitations; 1 laboratory; 4 credits.

#### **706. Advanced Network Theory**

Matrices, linear graph theory and the topological analysis of active and passive networks; concepts of natural frequencies and state; formulation and solution of state equations; application of linear graph and state techniques to real-world system problems. Prerequisite: Electrical Engineering 503, Electrical Circuit Theory. 4 credits.

#### **711. Digital Systems**

Generalized, systematic and practical approach to the logical design of digital systems encompassing circuit components, binary arithmetic, Boolean algebra, simplification methods, and derivation of application and input equations. Practical combinational circuits and logical arrays are emphasized in both synchronous and asynchronous applications. Logical equivalents are formulated together with the system aspects of interfacing digital communication systems, wiring and reliability considerations. Prerequisite: Senior status or above within the College of Technology or approval of the instructor. 3 recitations; 1 laboratory; 4 credits.

#### **712. Logical Design of Digital Computers**

Extension of EE 711 to the design of both general and special purpose digital computers. The design parameters of input-output; memory; and peripheral, arithmetic, and control units are established together with complete design equations for representative digital computers. Analog and hybrid methods are presented together with error-free techniques and a survey of research trends applicable to present and next generation computers. Prerequisite: Electrical Engineering 711 or approval of instructor. 3 recitations; 1 laboratory; 4 credits.

#### **725. Advanced Analysis of Machinery**

Steady-state and transient analysis of alternating and direct-current machines. Prerequisite: Electrical Engineering 520, Electromechanical Energy Conversion. 3 recitations; 1 laboratory or conference; 4 credits.

#### **727. Power Systems**

An introduction to the steady-state and transient analysis of large electrical power systems. Prerequisite: Electrical Engineering 520, Electromechanical Energy Conversion. 3 recitations; 1 laboratory or conference; 4 credits.

#### **730. Direct Energy Conversion**

Principle of operation and application of direct energy conversion devices. Devices studied will include fuel cells, thermoelectric and thermionic generators and magnetohydrodynamic generators and propulsion devices. Prerequisites: Mechanical Engineering 503, Thermodynamics I, or equivalent. 4 credits.

#### **741. Fundamentals of Acoustics**

The development of the acoustic wave equation for air; laws of reflection, refraction, and absorption; characteristics of acoustical sources; measurement of acoustic sources; microphones; measurement of sound level; properties of acous-

tical materials, ultra-sonics, architectural acoustics. Prerequisite: Physics 502, General Physics II; Mathematics 527, Differential Equations. 3 recitations; 1 laboratory; 4 credits.

### **757. Fundamentals of Communications**

Introduction to communications systems, Fourier analysis of signals, amplitude and frequency modulation, detection, digital and sampled data signals, noise in electrical circuits. 3 recitations; 1 laboratory; 4 credits.

### **758. Communication Systems**

Fundamentals of the design of high frequency communication systems. RF amplification, modulators for amplitude and frequency modulation systems, receiving techniques, antennas, free space propagation, propagation characteristics of the ionosphere. Prerequisite: Electrical Engineering 509, Electromagnetic Fields; 757; or equivalent. 3 recitations; 1 laboratory; 4 credits.

### **762. Illumination**

Radiation; color and spectra; physics of light to production; sources of ultraviolet, visible, and infrared energy; lamp circuitry; control of light; illumination design. The course will be conducted on a seminar basis with each student researching and discussing the above topics and doing a project in the application of visible or near-visible energy in business and industry, education, the ocean, agriculture, medicine, or other areas. 2 or 4 credits.

### **770. Integrated Circuit Design and Technology**

An introduction to the principles of operation, design, processing, and technology of linear and nonlinear integrated circuits. Bipolar and unipolar structures, including surface-controlled devices, will be considered. Related topics will include thin-film hybrid circuit techniques, vacuum technology, opto-electronic devices, and microwave active circuits. Prerequisites: Electrical Engineering 505, Electronic Properties of Materials and Devices and 510, Linear Electronic Circuits. 2 recitations; 2 laboratories; 4 credits.

### **781. Instrumentation**

Analysis and design of equipment for measurement, instrumentation, and control. 3 recitations; 1 laboratory; 4 credits.

### **782. Control Systems**

Fundamental principles involved in the design and analysis of feedback control systems. Topics include stability criterion, time-domain analysis, frequency-domain analysis, and introduction to nonlinear systems. 3 recitations; 1 laboratory; 4 credits.

### **783. Environmental Aspects of Engineering Design**

Examination of the impact of technology on the physical, social, economic, and political environment and the constraints imposed by these on engineering systems design. Course work will include readings of the history of technological growth and of current effects of the interaction between environment and technology, and seminar and workshop discussions and position papers on selected topics. Each student will, in lieu of a final examination, evaluate an engineering system design with respect to environmental impact. Prerequisite: Senior or graduate status within the College of Technology. 4 credits.

**784. Bioelectronics**

A study of topics in bioelectronics including biotelemetry, physiological transducers, and modeling. Animal systems such as the nervous system, circulatory system, the ear, and the eye will be studied from an engineering point of view. Prerequisite: Electrical Engineering 510, Linear Electronic Circuits, or equivalent. 4 credits.

**785. Underwater Acoustics**

An introduction to the field of underwater acoustics including vibrations, propagation, reflection, scattering, reverberation, attenuation, sonar equations, ray and mode theory, radiation of sound, transducers, and small and large signal considerations. Prerequisite: Senior or graduate status within the College of Technology. 4 credits.

**786. Introduction to Radio Astronomy**

Characteristics of electromagnetic radiation, propagation. Positional astronomy and the radio sky, discrete radio sources, source structure distribution, the sun as a radio source, flare and burst activity, planetary emissions, galactic background line emissions. (Hydrogen, Hydroxyl), quasars, pulsars, techniques of observation and data reduction, radiometry, polarimeters, correlation interferometers, aperture synthesis. Prerequisite: Senior or graduate status in Electrical Engineering or Physics. 4 credits.

**796. Special Topics in Electrical Engineering**

New or specialized courses are presented under this listing, on sufficient demand. Independent study can be given under this course title. Prerequisite: permission of instructor. 2 or 4 credits.

**801. Electromagnetic Field Theory**

Review of Maxwell's Equations. Green's function method for solution of electrostatic problems. Wave propagation in isotropic, anisotropic, and ionized media. Propagation over a plane earth, surface waves. Prerequisite: Electrical Engineering 701. 3 credits.

**802. Electromagnetic Wave Theory**

Diffraction and scattering; scattering from objects with edges and without edges; introduction to wave propagation in random and turbulent media. Prerequisite: Electrical Engineering 801. 3 credits.

**803. Microwave Systems**

Waveguide propagation—rectangular, cylindrical, and strip-line; microwave generation devices; impedance measurements; and signal collection detection. Propagation of microwaves at centimeter and millimeter wavelengths. Prerequisite: Electrical Engineering 801. 3 credits.

**804. Antennas**

Radiation of electromagnetic waves, current distribution on extended structures, antenna impedance considerations. Aperture antennas, parabolic reflectors, horns, lens. Multielement arrays, surface wave devices, aperture synthesis, phased arrays. Prerequisite: Electrical Engineering 801. 3 credits.

**811. Fundamentals of Signal Processing**

Introductory probability theory, matrices and determinants, introductory graph theory. Laplace transforms and pole-zero concepts, complex variable theory,

convolution, concept of state, formulation and solution of state equations. 3 credits.

### **812. Network Synthesis**

Synthesis techniques of linear, lumped, finite, passive, bilateral networks. The positive real concept. Realizability conditions. Realization of driving point and transfer functions, RC synthesis, active network synthesis, analysis and synthesis of integrated and thin film structures. Prerequisite: Electrical Engineering 811. 3 credits.

### **813. Nonlinear Networks**

Introduction to basic nonlinear phenomena and methods. Study of time-varying and nonlinear passive networks including free and forced responses, jump phenomena and subharmonic generations. Circle criterion, Popov's criterion and other frequency-domain stability criteria. Liapunov stability theory. Prerequisite: Electrical Engineering 811. 3 credits.

### **815. Linear Active Circuits**

Investigation of circuits, devices, and techniques used in linear applications. Heavy emphasis is placed on design, construction, and testing of linear circuits using both discrete solid-state devices and integrated circuits. 3 credits.

### **816. Nonlinear Active Circuits**

Investigation of circuits, devices, and techniques used in pulse and other non-sinusoidal applications. Heavy emphasis is placed on design, construction, and testing of digital circuits using both discrete solid-state devices and integrated circuits. 3 credits.

### **817. Network Analysis**

Topological properties and analysis of networks; one to n-port networks; natural frequencies; eigen values and state variables; parts of network functions, Fourier and Hilbert transforms; the approximation problem in the time—and frequency-domains. Prerequisite: Electrical Engineering 811. 3 credits.

### **831. Solid State Electronics I**

A study of topics in solid state electronics including semiconductor physics, crystal structure, band theory, transport phenomenon, recombination, and PN junctions. Semiconductor fabrication process theory will be introduced. Prerequisite: Electrical Engineering 505, Electronic Properties of Materials and Devices, or equivalent. 3 credits.

### **832. Solid State Electronics II**

A continuation of EE 831 emphasizing the theory of semiconductor devices including bipolar, field-effect, and surface-controlled transistors, monolithic and hybrid integrated circuits, photoconductors, injection luminescent diodes, semiconductor laser and bulk effect devices, as well as selected applications and topics in theory of semiconductor technology. Prerequisite: Electrical Engineering 831. 3 credits.

### **833. Solid State Electronics III**

A study of advanced topics in solid-state electronics either not covered in EE 831 and 832 or with coverage in considerable depth requiring extensive use of published literature and library resources. This course will allow and require

independent study of selected topics of current interest in solid state electronics. Prerequisite: Electrical Engineering 832. 3 credits.

**839. Statistical Theory of Communications**

An introduction to probability theory and random waveforms leading to a discussion of optimum receiver principles. Topics include random variables, random processes, correlation, power spectral density, sampling theory, and optimum decision rules. Prerequisite: Electrical Engineering 811. 3 credits.

**840. Information Theory**

A continuation of EE 839. Introduction of information-theory concepts. Topics include: message sources, entropy, channel capacity, fundamentals of encoding, Shannon's Theorems. Prerequisite: Electrical Engineering 839. 3 credits.

**851. Advanced Control Systems I**

State-space representation of systems. Analysis using state transition matrix. Controllability and observability. Synthesis of optimum control systems, including calculus of variations and maximum principle. Introduction to nonlinear and stochastic control systems including stability concepts using Liapunov and Popov criteria. Sampled-data systems. Prerequisite: Electrical Engineering 782. 3 credits.

**852. Advanced Control Systems II**

Special topics in control theory such as multivariate and adaptive control systems, stochastic systems, Wiener and Kalman filter techniques, introduction to dynamic, linear and nonlinear programming. Prerequisite: Electrical Engineering 851. 3 credits.

**854. Foundations of Systems Engineering**

Introduction to function space, i.e. Metric spaces, Banach spaces, Hilbert spaces, and transformations. Treat optimal control as a geometric problem on a Banach space and obtain minimum norm solutions. Sensitivity analysis of linear systems. Prerequisite: Electrical Engineering 852 or equivalent. 3 credits.

**856. Switching Theory**

Combinational circuits—including functional decomposition, non-binary logic, and cellular networks. Sequential networks—including analysis, transient behavior, state reduction methods, state assignment, and synthesis. Prerequisite: Electrical Engineering 711. 3 credits.

**891-892. Research**

3 credits each semester.

**898. Independent Study**

Independent theoretical and/or experimental investigation of an electrical engineering problem under the guidance of a faculty member. 1-3 credits per semester.

**899. Master's Thesis**

6 credits.

### English (49)

Chairman: *John C. Richardson*

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PROFESSORS: Robert D. Hapgood, William B. Hunter Jr., Donald M. Murray, Dale S. Underwood, Thomas Williams

ASSOCIATE PROFESSORS: Thomas A. Carnicelli, Lewis C. Goffe, Max S. Maynard, Edmund G. Miller, Philip L. Nicoloff, John C. Richardson, John A. Yount

ASSISTANT PROFESSORS: Anthony S. Caldwell, John J. Duffy, Terence P. Logan, Hugh M. Potter III, Mark Smith

The Department of English offers three advanced degrees, Master of Arts, Master of Science for Teachers, and Doctor of Philosophy. Applicants are expected to have done superior work in English at the undergraduate level. Applicants for the Master of Arts and the Ph.D. degrees are advised, but not required, to submit verbal aptitude and advanced literature scores on the Graduate Record Examinations. Applicants for the Ph.D. are normally expected to have a reading knowledge of at least one foreign language.

#### Master of Arts

The Master of Arts may be undertaken as a terminal degree or as preparation for a doctoral program. The program encourages students to pursue their individual interests and to correct serious deficiencies in their undergraduate training.

COURSES: A Master's candidate must pass seven four-credit courses in English and American literature and language. Five courses, including at least two graduate seminars, must be at the 800 level, and no more than two at the 700 level. Students should normally take their non-seminar courses in fields where they have had little previous experience.

LANGUAGE: A Master's candidate must pass a reading examination in one of the following languages: French, German, Greek, Italian, Latin, Russian, Spanish.

THESIS: Each Master's candidate must write an acceptable thesis. The thesis will normally be a scholarly paper of approximately fifty typed pages in length, and may be a development of a seminar paper. The Department occasionally accepts a body of creative writing (a novel, a collection of short stories, poems, essays) as fulfilling the thesis requirement. The complete first draft of the thesis must be submitted to the student's advisors at least two months before the degree is to be granted. The final copies must be ready for signing at least three weeks before the degree is to be granted.

#### Master of Science for Teachers

The Master of Science for Teachers is a terminal degree designed for the high school teacher. No foreign language is required. The student must take eight courses in English numbered above 700 that will not be a repetition of his undergraduate work. Applicants should consult the General Regulations of the Graduate School for the special admissions requirements for this program.

#### Doctor of Philosophy

The Ph.D. program offers professional training in the study and teaching of literature and language. The program combines the essential guidance and discipline of course work with the equally essential freedom of independent study and research. Accordingly, the first year of study lays primary stress upon courses, while

the second and subsequent years encourage the student to follow a program suited to his individual interests and needs. In addition to meeting course requirements, each student must pass reading examinations in two foreign languages (French, German, Greek, Italian, Latin, Russian, Spanish), and written qualifying examinations in five areas of English and American literature and language. He must also acquire some experience of the methods and problems of teaching, either by completing a seminar in college teaching or by teaching for a year under supervision as a graduate assistant within the department. Finally, he must write a dissertation and defend it at a final oral examination. The program is designed to be completed within four years of full-time study. At present students will not be permitted to write dissertations in the following fields: English Language, Eighteenth-Century British Literature, and Twentieth-Century British Literature.

A complete guide to the Department's graduate programs is available from the chairman of the graduate committee.

**701-702. Advanced Writing of Fiction and Poetry**

Workshop discussions of advanced writing problems, and readings of students' fiction, poetry, or plays. Individual conferences. Mr. Williams. Written permission of instructor required for registration. 4 credits.

**703-704. Advanced Non-Fiction Writing**

A workshop course for advanced students of writing, with discussions and individual conferences. Mr. Murray. Written permission of instructor required for registration. 4 credits.

**705. English Grammar**

A review of English grammar including both traditional and contemporary approaches. Mr. Goffe. 4 credits.

**706. English Linguistics**

A descriptive approach to modern English grammar, emphasizing the insights provided by linguistic analysis. Mr. Hunter. 4 credits.

**709, 710. Critical Analysis of Exposition and Fiction**

709, Exposition; 710, Fiction. 4 credits.

**711. Critical Analysis of Poetry and Drama**

A non-historical, non-genre approach to individual poems and plays with emphasis on the works themselves. Mr. Richardson. 4 credits.

**713, 714. Literary Criticism**

Major critics from Plato to the present and the chief critical approaches to literature. 4 credits.

**742. Puritanism and the Enlightenment in America**

American literature and thought from the Colonial beginnings through the early republic. Mr. Duffy. 4 credits.

**743. American Transcendentalists**

Emerson, Thoreau, and other transcendentalists. (Formerly English 775.) Mr. Duffy. 4 credits.

**744. American Fiction to the Civil War**

Cooper, Poe, Hawthorne, Melville, and others. (Formerly English 776.) Mr. Goffe. 4 credits.

**745. American Poetry of the Nineteenth Century**

Bryant, Poe, Emerson, Whitman, Dickinson, and others. (Formerly English 777.) 4 credits.

**746. American Realism and Naturalism**

Twain, Henry James, Adams, Stephen Crane, Dreiser, and others. 4 credits.

**747, 748. American Fiction and Drama of the Twentieth Century**

Fitzgerald, Hemingway, O'Neill, Faulkner, and others. (Formerly English 779, 780.) Mr. Nicoloff and Mr. Potter. 4 credits.

**749. American Poetry of the Twentieth Century**

Robinson, Frost, Stevens, Pound, Eliot, Jeffers, Hart Crane, Robert Lowell, and others. Mr. Nicoloff. 4 credits.

**751. History of the English Language**

A study of the evolution of the English language, with special emphasis upon the relation between linguistic change and literary style. Mr. Carnicelli. 4 credits.

**753. Old English**

An introduction to Old English language and literature through readings of selected poetry and prose. Mr. Carnicelli. 4 credits.

**754. *Beowulf***

A reading of the poem and an introduction to the scholarship. Mr. Carnicelli. Prerequisite: English 753. 4 credits.

**755, 756. Chaucer**

755: Chaucer's allegorical poems and *Troilus and Criseyde*.

756: *The Canterbury Tales*. Mr. Underwood. 4 credits.

**757, 758. Shakespeare**

The major plays of Shakespeare. 757 surveys a number of representative plays; 758 studies a few plays more intensively. 757 is prerequisite to 758. Mr. Hapgood, Mr. Hunter, Mr. Logan. 4 credits.

**759. Milton**

Milton's life and times, all his poetry, and a selection of his prose. Mr. Hunter. 4 credits.

**763, 764. English Literature in the Sixteenth Century**

763: Major literary figures of the continental Renaissance (in translation), including Petrarch, Machiavelli, Ariosto, Rabelais, Montaigne, Cervantes, and Erasmus; major English writers of the period, including More, Skelton, Wyatt, and Surrey. 764: Sidney, Drayton, and other late Elizabethans, with emphasis upon Spenser. Mr. Logan. 4 credits.

**765, 766. English Literature in the Seventeenth Century**

765: Major writers of prose and poetry in the first half of the century; special emphasis upon the relationships between the metaphysical and the classical



modes of poetry. 766: Restoration comedy of manners, heroic drama, verse satire, Dryden, Milton, and Bunyan. Mr. Underwood. 4 credits.

**767, 768. English Literature in the Eighteenth Century**

767: Addison, Steele, Defoe, Pope, and Swift. 768: Gray, Collins, the Wartons, Burke, Goldsmith, Reynolds, Johnson, Boswell, Crabbe, Burns, and Blake. Mr. Maynard. 4 credits.

**769. The English Romantic Period**

Wordsworth, Coleridge, Lamb, Hazlitt, DeQuincey, Byron, Shelley, and Keats. Mr. Miller. 4 credits.

**771, 772. Victorian Prose and Poetry**

771: Carlyle, Mill, Ruskin, Newman, Tennyson, and Browning. 772: Arnold, Clough, the Pre-Raphaelites, Swinburne, Hardy, Housman, and others. Mr. Miller. 4 credits.

**773, 774. British Literature of the Twentieth Century**

773: Conrad, Joyce, Yeats, and others. 774: Lawrence, Eliot, Auden, Dylan Thomas, and others. Mr. Richardson. 4 credits.

**781, 782. Introduction to English Drama**

The development of English drama, exclusive of Shakespeare, from the Middle Ages to the present. 781: From the Middle Ages to the closing of the theatres in 1642. 782: From the Restoration to the present. 4 credits.

**783. The English Novel of the Eighteenth Century**

4 credits.

**784. The English Novel of the Nineteenth Century**

One representative novel of each of the following: Jane Austen, Scott, Dickens, Thackeray, Emily Bronte, Charlotte Bronte, Trollope, George Eliot, and Hardy. 4 credits.

**791. (English Education) Problems in the Teaching of High School English**  
Principles and methods of teaching literature, composition, and language in secondary schools. Mr. Goffe. Prerequisite: a grade of C or better in Education 658. 4 credits.

**795, 796. Independent Study**

Individual guided study in special topics. Open to MST candidates. Open under special circumstances to MA candidates upon petition to the departmental graduate committee. Graduate faculty. 14 credits.

**797, 798. Special Studies in Literature**

The precise topics and methods of each section will vary.

- |                                |                          |
|--------------------------------|--------------------------|
| 1. Old English Literature      | 8. The Twentieth Century |
| 2. Medieval Literature         | 9. The Drama             |
| 3. The Renaissance             | 10. The Novel            |
| 4. The Seventeenth Century     | 11. Poetry               |
| 5. The Eighteenth Century      | 12. Non-fiction          |
| 6. The English Romantic Period | 13. American Literature  |
| 7. The Victorian Period        | 14. A Literary Problem   |
- Graduate faculty. 4 credits.

**813, 814. Literary Criticism**

4 credits.

**842. Puritanism and the Enlightenment in America**

4 credits.

**843. American Transcendentalists**

4 credits.

**844. American Fiction to the Civil War**

4 credits.

**845. American Poetry of the Nineteenth Century**

4 credits.

**846. American Realism and Naturalism**

4 credits.

**847, 848. American Fiction and Drama of the Twentieth Century**

4 credits.

**849. American Poetry of the Twentieth Century**

4 credits.

**851. History of the English Language**

4 credits.

**853. Old English**

4 credits.

**854. *Beowulf***

4 credits.

**855, 856. Chaucer**

4 credits.

**857, 858. Shakespeare**

4 credits.

**859. Milton**

4 credits.

**863, 864. English Literature in the Sixteenth Century**

4 credits.

**865, 866. English Literature in the Seventeenth Century**

4 credits.

**867, 868. English Literature in the Eighteenth Century**

4 credits.

**869. The English Romantic Period**

4 credits.

**871, 872. Victorian Prose and Poetry**

4 credits.

- 873, 874. British Literature of the Twentieth Century**  
4 credits.
- 881, 882. Introduction to English Drama**  
4 credits.
- 883. The English Novel of the Eighteenth Century**  
4 credits.
- 884. The English Novel of the Nineteenth Century**  
4 credits.
- 885, 886. Seminar — Problems in Medieval Literature**  
Mr. Underwood. 4 credits.
- 887. Seminar — Studies in Sixteenth-Century Literature**  
Mr. Logan. 4 credits.
- 888. Seminar — Problems in Milton Scholarship and Criticism**  
Mr. Hunter. 4 credits.
- 889. Seminar — Studies in Shakespeare**  
Mr. Hapgood. 4 credits.
- 890. Seminar — Studies in English Drama**  
Mr. Hapgood. 4 credits.
- 891. Seminar — Studies in American Literature of the Nineteenth Century**  
Mr. Nicoloff or Mr. Duffy. 4 credits.
- 892. Seminar — Studies in Restoration Literature**  
Mr. Underwood. 4 credits.
- 893. Seminar — Studies in Early Seventeenth-Century Literature**  
Mr. Hunter or Mr. Underwood. 4 credits.
- 894. Seminar — Studies in the Romantic Period**  
Mr. Miller. 4 credits.
- 895, 896. Reading and Research**  
Graduate Faculty. 4 or 8 credits.
- 897, 898. Special Studies in Literature**  
Graduate Faculty. 4 credits.
- 899. Master's Thesis**  
6 credits.
- 999. Doctoral Research**

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## Engineering Ph.D. Program

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Consult the College of Technology for information about the Engineering Doctoral (Ph.D.) Program in the following areas: Computer Graphics, Design, Signal Processing, Solid and Structural Mechanics, and Systems.

### Entomology (29)

Acting Chairman: *Robert L. Blickle*

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PROFESSORS: Robert L. Blickle, James G. Conklin

ASSISTANT PROFESSOR: R. Marcel Reeves

For admission to graduate study in Entomology an applicant is expected to have adequate preparation in undergraduate Entomology and related sciences. Students lacking the necessary background courses may be required to complete certain courses which do not carry credit before they are admitted to candidacy for a degree.

The program of graduate study is designed to meet the needs of those students who are planning to take further work leading to a career in professional entomology.

A thesis is required of all candidates for the Master's degree.

#### 704. Medical Entomology

Insects and arachnids in relation to public health. The more important disease carriers, their biologies, and means of control. Adapted especially for students who are interested in public health or medicine. Elective for juniors and seniors. Mr. Blickle. 2 lectures; 1 laboratory; 4 credits.

#### 707-708. Advanced Entomology

The anatomy and physiology of insects. Aquatic and systematic entomology. Mr. Conklin and Mr. Blickle. Open to others than Entomology majors by permission of Department Chairman. 2 lectures; 1 laboratory; 4 credits.

#### 709-710. Advanced Economic Entomology

Problems in applied Entomology; the literature of economic entomology. Investigational methods. Studies of the specialized phases of entomology. Mr. Conklin and Mr. Blickle. Required of Entomology majors. Open to others than Entomology majors by permission of Department Chairman. 2-4 credits.

#### 801, 802. Graduate Entomology

Concentrated studies in insect biology, systematics, and biological control or chemical control of insects. Mr. Conklin and Mr. Blickle. Subject matter, hours, and credits to be arranged.

#### 899, (899). Graduate Entomology—Master's Thesis

Mr. Conklin, Mr. Blickle, and Mr. Reeves. Hours and credits to be arranged. 6-10 credits.

# Forest Resources (30)

Chairman: *Otis F. Hall*

PROFESSORS: Paul E. Bruns, Otis F. Hall

ASSOCIATE PROFESSORS: James P. Barrett, Bennett B. Foster, John L. Hill, Harold W. Hocker Jr., David P. Olson, Oliver P. Wallace

ASSISTANT PROFESSORS: William W. Mautz, R. Marcel Reeves, Roger P. Sloan, Richard R. Weyrick

Students admitted to graduate study in Forestry are expected to have completed a course of study equivalent to that required for the degree of Bachelor of Science in Forestry. Those lacking this training may be admitted to candidacy after completing certain courses without graduate credit. Candidates for the Master of Science in Forestry degree must pass an oral examination. A thesis may not be required.

Present courses, research projects, and faculty specializations permit design of individual graduate programs in:

Natural Resource Management	Forest Tree Improvement
Wood Industry Management	Wood Science and Technology
Forest Mensuration	Forest Marketing

Graduate study leading to the Master of Science, major in Wildlife Management, is available in either the Department of Forest Resources or through a cooperative program with the Department of Animal Sciences.

## 702. Natural Resources Policy

Contemporary issues in the management and allocation of natural resources. The impact of human activity and demands on resources, including agricultural and forest lands, water, wildlife, fisheries, and minerals. Historical perspective as it contributes to an understanding of current public and private resource policies. Mr. Bruns, Mr. Weyrick, Mr. Bowring, Mr. Drew. Prerequisite: permission of instructor. 4 credits.

## 711. Statistical Methods II

An intermediate course in statistics. Topics include basic concepts of sampling, linear models, and analyses for one-way and multi-way classifications; factorial arrangement of treatments; multiple regression; and covariance. Computer programs used in analyzing data. Mr. Barrett. Prerequisite: Forest Resources 528 (Applied Statistics) or equivalent. 4 credits.

## 712. Sampling Techniques

A study of the techniques of sampling a finite population. Topics include choice of sampling unit and frame, estimation of sample size, confidence limits, and comparisons of sample designs. Computer programs used in analyzing data. Mr. Barrett. Prerequisite: Forest Resources 528 (Applied Statistics) or equivalent. 4 credits.

## 720. Forest Tree Improvement

The genetics of forest tree improvement with emphasis on variation in natural populations, the basis for selection of desired characters, and the fundamentals of controlled breeding. The application of principles will be directed toward silviculture, management and utilization. Mr. Hocker. Prerequisite: permission

of instructor. 3 lectures; 1 laboratory; 4 credits. (Alternate years; offered in 1971-72.)

### **737. Game Management I**

Biological characteristics, habitat usage, research, and management techniques of *upland game birds and big game mammals*. Students should be prepared for weekend field trips to wildlife areas in New England. Mr. Olson. Prerequisite: wildlife management major or consent of instructor. 2 lectures; 1 recitation; 1 laboratory; 4 credits.

### **738. Game Management II**

Biological characteristics, habitat usage, research, and management techniques of *small game mammals, furbearers, and waterfowl*. Students should be prepared for weekend field trips to wildlife areas in New England. Mr. Olson. Prerequisite: wildlife management major or consent of instructor. 2 lectures; 1 recitation; 1 laboratory; 4 credits.

### **745. Forest Management**

Production control in forests with many uses and management objectives. Analysis of silvicultural, economic, and business problems. Practice of forest administration. Professional responsibilities and opportunities. Mr. Weyrick and Mr. Bruns. Prerequisite: completion of junior year in forestry curriculum. 3 lectures; 1 laboratory; 4 credits.

### **753. Operations Control and Analysis**

Applications of economic principles to the control and analysis of harvesting, manufacturing and other timber-based operations. The use of quantitative methods in developing cost functions, mathematical programming, PERT, game theory, simulation, and scheduling problems. Mr. Foster. Prerequisite: forest biometrics and forest economics. 4 credits.

### **754. Wood Products Manufacture and Marketing**

A study of the wood products manufacturing industry from the harvesting and procurement of raw material to finished product processes with emphasis on management decisions, marketing, and promotion problems. Visits to harvesting operations and manufacturing plants in the New England region are used as the basis for study. Mr. Hill. Prerequisite: Forest Resources 426 (Wood Technology) and 753. 3 lectures; 1 laboratory; 4 credits.

### **758. Photogrammetry in Forestry**

Elementary principles of photogrammetry with emphasis on their application to all phases of forestry. The value and use of aerial photos in forest typing, planimetric, and topographic mapping; measurement of area and volume estimation. Mr. Bruns, Mr. Barrett. Prerequisite: permission of instructor. 2 lectures; 2 laboratories; 4 credits.

### **764. Forest Industry Economics**

Application of business methods and economics in the establishment and operation of forest industries; planning for minimum-cost operation and the profitable use of capital in forest enterprises. Mr. Wallace. Prerequisite: senior standing and permission of instructor. 4 credits.

**797. Forest Recreation Seminar**

The recreational use of forest lands, including factors that affect demand and supply for recreation. Planning for state and local recreational use, emphasizing the economic and social aspects. Mr. Wallace. Prerequisite: junior standing and permission of instructor. Two 2-hour sessions; 4 credits.

**798. Forest Resources Management Seminar**

Population trends and human needs in relation to forest-land productivity for timber, wildlife, water, recreation, and grazing. Organized groups involved in forest land use and management, and overall planning to help maximize forest-land use and productivity for our society. Mr. Wallace. Prerequisite: Forest Resources 745. 4 credits.

**801, 802. Forest Management Seminar**

Seminar discussions of current literature, plans, and principles and new developments in the general field of forest management. Mr. Bruns and members of the department. Prerequisite: permission of instructor. 2 credits.

**803. Approach to Research**

The meaning of science and the scientific method. The application of logic in the scientific method. The general principles and techniques of scientific research. A general survey of statistical procedures as a tool for research. The organization of investigative work including problems analyses, working plans, and the preparation of reports. Mr. Foster and members of the department. Prerequisite: permission of instructor. 2 credits.

**805. Utilization Seminar**

Conferences, discussions, and reports on assigned topics. Consideration of current literature and developments in the general field of wood utilization. Mr. Hill. Prerequisite: permission of instructor. 2-hour seminar; 2 credits.

**806. Operations Control Seminar**

Conferences, discussions, and reports on assigned topics. Considerations of current development in the field of quantitative control of forest operations. Mr. Foster. Prerequisite: permission of instructor. 2-hour seminar; 2 credits.

**809, 810. Wildlife Management Seminar**

Discussions and assigned reports on current investigations and developments in wildlife management. Mr. Olson. Prerequisite: undergraduate courses in wildlife management. 2-hour seminar; 2 credits.

**815. Advanced Mensuration**

Volume-table construction and application, advanced studies of growth and yield, and methods of prediction. Application of graphic and statistical solutions to these problems. Mr. Barrett. Prerequisite: permission of instructor. 2 lectures; 1 laboratory; 3 credits.

**818. Advanced Photogrammetry in Forestry**

The application of aerial photogrammetrical techniques to specific forestry problems. The use of photographs for volume estimation including cull, volume tables, and species composition; use in fire control; range, timber, and recreational management; road location; allocation of cut; and design of large-

## French and Italian

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scale resource inventories. Mr. Bruns and Mr. Barrett. Prerequisite: permission of instructor. 2 credits.

### 833. Forest Protection Seminar

Discussion and special problems based on principles and techniques of forest protection. Mr. Weyrick. Prerequisite: Forest Resources 660 (Forest Protection) or equivalent. 3 credits.

### 861, 862. Investigations in (1) Forest Ecology, (2) Photogrammetry,

(3) Wood Utilization, (4) Game Management, (5) Mensuration, (6) Forest Economics, (7) Forest Management, (8) Logging Economics  
Work to be arranged according to the needs of individual students. Staff.  
Hours to be arranged. Prerequisite: permission of instructor. 2-4 credits.

### 899. Thesis

Hours and credits to be arranged to meet the needs of the individual student. Prerequisite: graduate standing and permission of instructor in the selected field of study. 6-10 credits.

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## French and Italian

Chairman: *Louis J. Hudon*

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PROFESSOR: Louis J. Hudon

ASSOCIATE PROFESSOR: Samuel E. Stokes Jr.

VISITING ASSOCIATE: Edna S. Hudon

ASSISTANT PROFESSOR: Grover E. Marshall

The Department of French and Italian offers courses leading to two degrees, Master of Arts and Master of Science for Teachers in French.

To be admitted to graduate study for the Master of Arts degree, a student must have completed an undergraduate major in French or the equivalent thereof. He must also submit scores of the Graduate Record Examination, both the Aptitude Test and the Advanced Test in French.

To satisfy requirements for the Master of Arts degree, the student must complete 8 courses and write a master's thesis. Six of the courses must be in French, four among French courses numbered 800 or above. Two of the eight courses may be taken in related departments. The thesis must embody results of independent investigation and be written in a form acceptable to the Department. It must be submitted to the thesis director before April 20 of the academic year in which the degree is to be granted.

To be admitted to graduate study for the Master of Science for Teachers degree in French, a candidate must meet requirements as specified on page 19.

To satisfy course requirements for the Master of Science for Teachers degree, the student must complete 10 courses. Six must be in French, four from French courses numbered 800 or above; two of the courses may be taken in related departments; and two may be transferred from an accredited NDEA institute, offering graduate courses.



The candidate for the Master of Science for Teachers degree must pass a departmental oral and written examination on or before April 20 of the academic year in which the degree is to be granted.

All courses in the Department are conducted in French.

## French (56)

### 807, 808. Comparative Literature

For 1970-71, a study of the European novel of the 20th century, taught by members of the faculty of the Departments of English, French and Italian, German and Russian, and Spanish and Classics. 3 credits.

### 841. French Literature of the Middle Ages

Readings in the epic, lyric poetry, and the romance. 3 credits. (Alternate years; offered in 1970-71.)

### 842. French Literature of the Renaissance

Readings in the literature of the sixteenth century. 3 credits. (Alternate years; offered in 1970-71.)

### 859-860. French Literature of the Seventeenth Century

Readings in the literature of the seventeenth century. 3 credits. (Alternate years; not offered in 1970-71.)

### 861-862. Eighteenth Century French Literature and Thought

Readings in the Age of Enlightenment and *belles lettres* of the period. 3 credits. (Alternate years; offered in 1970-71.)

### 867-868. Nineteenth Century French Literature

Readings in Romantic, Parnassian, and Realistic literature of the century. 3 credits. (Alternate years; not offered in 1970-71.)

### 870. Introduction to Modern French Poetry

Studies in French Poetry from Baudelaire to the present. 3 credits. (Alternate years; not offered in 1970-71.)

### 881-882. Contemporary French Novel and Theater

Readings in the French novel and theater of the twentieth century. 3 credits. (Alternate years; offered in 1970-71.)

### 888. Seminar in French Literature

A study of French authors chosen by the instructor. 3 credits. (Alternate years; not offered in 1970-71.)

### 890. Advanced Language and Style

Translation of literary texts, intensive study of the principle techniques of style, *explication de textes*. 3 credits.

### 895, 896. Special Studies in French Language and Literature

Individual, guided study in special topics, with training in bibliography and organization of material. Examples of topics which may be selected are: the work of a major French author, specific topics in any area of French literature, such as literary criticism in a given period. Prerequisite: permission of the department chairman. 4 credits.

## Genetics Program

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### 899. Master's Thesis

6 credits.

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## Genetics Program (97)

Chairman: *D. MacDonald Green*

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PROFESSORS: Walter M. Collins, Gerald M. Dunn, D. MacDonald Green, Lincoln C. Peirce, Richard W. Schreiber

ADJUNCT PROFESSOR: Ernst J. Schreiner

ASSOCIATE PROFESSORS: Frank K. Hoornbeck, James P. Barrett, Harold W. Hocker Jr., Owen M. Rogers, Willard E. Urban Jr.

ASSISTANT PROFESSORS: Fred T. Hickson, J. Brent Loy

The interdepartmental Genetics Program offers graduate work leading to the degrees of Master of Science and Doctor of Philosophy.

A qualified student is admitted to the program with the approval of the chairman of the department in which he has a major interest. Students will be expected to have adequate preparation in the biological and physical sciences including mathematics. Students lacking these requirements may be admitted but will be required to complete certain courses without graduate credit.

The Program is conducted by faculty members from the departments of Animal Sciences, Biochemistry, Botany, Forest Resources, Microbiology, Plant Science, and Zoology as well as other faculty from the Agricultural Experiment Station and the U. S. Forest Service, Northeastern Forest Experiment Station. Areas of specialization in the program are: the genetics of plants, animals, microorganisms, and viruses, with emphasis in physiological and quantitative genetics. All students working toward the M.S. or Ph.D. degree in Genetics are required to satisfy the core-curriculum (Genetics 703, 705 and 770) requirements unless equivalent courses have been satisfactorily completed elsewhere.

### Master of Science Degree

The program for the Master of Science degree is formulated by the student with the approval of his guidance committee. Candidates for the degree will be required to complete a thesis, pass an oral examination covering graduate courses and thesis, and complete any two of the three courses of the core-curriculum.

### Doctor of Philosophy Degree

The chairman of the Genetics Program, with the concurrence of the chairman of the department of major interest, will nominate the student's guidance and doctoral committees. Specific course requirements will be developed by the student and his guidance committee, and will include the courses in the core-curriculum. Students must complete a dissertation on original research in genetics.

A student must satisfy a foreign language requirement by demonstrating proficiency in one language through successful completion of an E.T.S. Language Exam.

## Courses Available in the Genetics Program

### 703. Genetics

A course intended for students desiring more detailed training in fundamental genetics. This course and Genetics 705 and 770 are required for Genetics students. May be elected by others. Mr. Hoornbeek. Prerequisite: Zoology 604 or equivalent. 3 lectures; 1 laboratory; 4 credits. (Not offered in 1970-71).

### 705. Population Genetics

The distribution of genes in populations; factors affecting gene frequency such as mode of inheritance, departures from random mating, mutation, genetic drift, linkage disequilibrium, migration, selection, and fitness. Prerequisite: Zoology 604 and Forest Resources 528 or equivalents or permission of instructor. 4 credits. (Alternate years; offered in 1970-71.)

### 770. Biochemical Genetics

The biochemical mechanism of storage, replication, transmission, transcription, recombination, mutation, and expression of genetic information by cells and viruses. Mr. Green. Prerequisite: Biochemistry 751 or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

### 802. Design of Experiments

The philosophy of experimental design and how it relates to standard statistical designs. Topics include the roles of replication and randomization, factorially arranged treatments, latin squares, incomplete non-factorial designs, fractional replication and confounding, and cross-over designs. Mr. Urban. Prerequisite: Forest Resources 711 and Mathematics 410 or permission of instructor. 3 credits. (Alternate years; not offered in 1970-71.)

### 812. Advanced Statistical Methods

Methods and techniques for handling typical problems which arise in the analysis of data. Topics include the multiple comparison of means, analysis of unweighted means, proportional subclass numbers, weighted squares of means, orthogonal polynomials, and least squares. Mr. Urban. Prerequisite: Forest Resources 711 and Mathematics 410 or permission of instructor. 3 credits. (Alternate years; offered in 1970-71.)

### 821. Biometrical Genetics

Statistical aspects of estimating genetic parameters associated with quantitative traits. The theory underlying estimation of components of variance from various experimental designs, phenotypic and genotypic correlations, construction of selection indices, and the use of collateral and ancestral relatives to estimate breeding value. Mr. Urban. Prerequisite: Genetics 812, Mathematics 410, and either Animal Science 703 or Plant Science 774. 3 credits. (Alternate years; offered in 1970-71.)

### (898), 898. Genetics Seminar

Presentation and discussion of selected genetic topics. Staff. 1 credit. May be repeated.

### 899, (899). Master's Thesis

6-10 credits.

### 999,(999). Doctoral Research

### Courses Available in the Cooperating Departments

These courses are fully described below and under the course descriptions of the appropriate department for the convenience of the student.

#### Animal Sciences (25)

##### 708. Animal Genetics

Mendelian and quantitative inheritance in animals. Principles and systems of selection. Mr. Collins. Prerequisite: one course in genetics or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

##### 811. Quantitative Genetics and Animal Improvement

Gene frequency, genetic and environmental variation, heritability, fitness, selection, inbreeding, outbreeding, and correlated characters. Mr. Collins. Prerequisite: one course each in genetics and statistics. 3 credits.

#### Botany (27)

##### 732. Cytology

The structure, physiological behavior, and development of cells. The cellular basis of heredity. Mr. Schreiber. Prerequisite: one year each in the biological sciences and in chemistry. 3 lectures; 1 seminar; 4 credits.

##### 765. Microtechnique

A methods course in embedding, sectioning, and staining plant tissues, and an introduction to microscopy. Miss Nast. Prerequisite: Botany 411 or 503. 2 lectures; 4 hours of laboratory; 4 credits. (Alternate years; offered in 1970-71.)

#### Forest Resources (30)

##### 711. Statistical Methods II

An intermediate course in statistics. Topics include basic concepts of sampling, linear models and analyses for one-way and multiway classification, factorial arrangement of treatments, multiple regression, and covariance. Mr. Barrett. Prerequisite: Forest Resources 528 or equivalent. 4 credits.

##### 730. Forest Tree Improvement

The genetics of forest tree improvement with emphasis on variation in natural populations, the basis for selection for desired characters, and the fundamentals of controlled breeding. The application of principles will be directed toward silviculture, management, and utilization. Mr. Hocker. Prerequisite: permission of instructor. 2 lectures; 1 laboratory; 4 credits. (Alternate years; not offered in 1970-71.)

#### Microbiology (47)

##### 804. Microbial Genetics

An introduction to genetic principles and methodology applicable to microorganisms; fine structure of genetic material, mutation, selection, adaptation, recombination, transformation, and transduction. Mr. Hickson. Prerequisite: permission of instructor. 2 lectures; 2 laboratories; 4 credits.

## Plant Science (32)

### 773. Methods and Theory of Plant Breeding

Theory and use of plant breeding systems with emphasis on improving quantitative traits. Mr. Pierce. Prerequisite: Genetics, Statistics. 4 credits. (Alternate years; offered Fall 1970.)

### 832. Developmental Genetics

Relation to protein, RNA, and DNA synthesis in development, chromosome differentiation, nuclear-cytoplasmic interactions, genic and non-genic control of subcellular organization, cellular continuity, cell associations, experimental embryology, hormones and postembryonic development, gene regulation in development, and neoplastic growth. Mr. Loy. Prerequisite: permission of instructor. 3 credits. (Alternate years; offered Spring 1971.)

### 851. Plant Genetics

Linkage, euploidy, aneuploidy, cytoplasmic inheritance, mutation, and genetics of disease resistance. Mr. Dunn. Prerequisite: Genetics. 3 credits. (Alternate years; not offered in 1970-71.)

### 853. Cytogenetics

Chromosome aberrations and their behavior. Effect of radiation on chromosomes. Mapping and laboratory technique in cytogenic analysis. Mr. Rogers. Prerequisite: Genetics and Cytology. 2 lectures; 1 laboratory; 3 credits. (Alternate years; offered Fall 1970.)

## Geology (51)

Chairman: *Herbert Tischler*

PROFESSORS: Donald H. Chapman, T. Ralph Meyers, Cecil J. Schmeer, Herbert Tischler

ASSOCIATE PROFESSORS: Henri E. Gaudette, Glenn W. Stewart

ASSISTANT PROFESSORS: Franz E. Anderson, Wallace A. Bothner, William J. Wiseman

Admission to graduate study in Geology will be granted to applicants who have had adequate preparation in the geological and cognate sciences. Students lacking these requirements may be admitted, but will be required to complete certain courses which do not give graduate credit. A candidate for the Master's degree shall pass an oral or written examination covering his graduate courses and his thesis.

### 725. Petrology-Petrography

The identification and classification of igneous, metamorphic, and sedimentary rocks in hand specimen and thin section with emphasis on mineralogic and textural relationships leading to an understanding of petrogenesis. Mr. Bothner. Prerequisite: Geology 614, Mineralogy, or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

### 741. Geochemistry

Applications of thermodynamics to geological processes; geochemical differentiation of the earth; the principles and processes which control the distribution and migration of elements in geological environments. Mr. Gaudette. Prerequisite: Geology 614, Mineralogy, or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

### **754. Sedimentation-Stratigraphy**

The properties of sediments and sedimentary rocks, with emphasis on lithofacies, biofacies, principles of stratigraphic correlation, and sedimentary tectonics. Mr. Anderson and Mr. Tischler. Prerequisite: Geology 614, Mineralogy, or permission of instructor. 2 lectures; 1 laboratory; 4 credits.

### **758. Physical Oceanography**

An introduction to the physics of the oceans in sufficient scientific and mathematical detail to permit understanding of the current oceanographic literature. Both the descriptive and dynamic concepts of physical oceanography will be treated. Mr. Wiseman. Prerequisite: permission of instructor. 3 lectures; 1 student project; 4 credits.

### **759. Geological Oceanography**

Geologic properties of the earth that are unique to the continental shelves and ocean basins. Special emphasis will be placed on submarine geomorphology, eustatic sea level changes, crustal and subcrustal oceanic structure, and the evolution of the ocean basins. Mr. Anderson. Prerequisite: Geology 501 and Geology 754. 2 lectures; 1 discussion group; 1 special project; 4 credits.

### **771. Economic Geology**

The distribution, utilization, and geology of mineral fuels and some related materials. Mr. Meyers. Prerequisite: Geology 402. 4 credits.

### **781. Physical Geology**

The materials and structures of the earth and the erosive agents that modify them are described in the lectures and are examined and studied in the laboratory and on field trips. This course is for certified elementary or high school science teachers who need an introduction to the earth sciences. (Not available for credit after completing Geology 401 or equivalent.) 4 credits.

### **782. Historical Geology**

The history and development of the physical features of the earth and the development of life on the earth. Fossil organisms will be briefly surveyed in the laboratory and the methods of historical geology will be illustrated in the laboratory and on field trips. Prerequisite: Geology 781 or equivalent. This course is for certified elementary or high school science teachers who need an introduction to the earth sciences. (Not available for credit after completing Geology 402 or equivalent.) 4 credits.

### **795. Geological Problems**

(1) Areal Geology, (2) Geochemistry, (3) Geomorphology, Advanced, (4) Geophysics, (5) Glacial Geology, Advanced, (6) Groundwater Geology, (7) Historical Geology, Advanced, (8) Industrial Minerals, (9) Micropaleontology, (10) Mineral Fuels, (11) Mineralogy, Advanced, (12) Optical Crystallography, (13) Ore Deposits, (14) Paleontology, Advanced, (15) Petrology, Advanced, (16) Regional Geology, (17) Sedimentation, (18) Stratigraphy, (19) Structural Geology, Advanced, (20) Marine Geology, (21) Physical Oceanography

Special problems by means of conferences, assigned readings, and field or laboratory work, fitted to individual needs from one of the areas listed above. Staff. 2 or 4 credits.

**796. Honors Project**

Independent research projects similar to Geology 795 for students with 3.0 or better average in Geology. Staff. 2 or 4 credits.

**797. Geology Colloquium**

Study of selected topics in both classical and modern geological thought. Designed for geology and earth science majors. 0 credit.

**813. X-ray Crystallography**

The theory and practice of diffraction of X-rays by crystals; lattices, symmetry, and structure analysis. Mr. Schneer. Prerequisite: Geology 613, Mineralogy, or Physical Chemistry or equivalent. 3 credits.

**816. Mineralogy of Clays**

The mineralogic composition of clays; the structure and properties of the clay minerals; origin and mode of occurrence of the clay minerals and clay materials. Prerequisite: permission of the instructor. Mr. Gaudette. 3 credits. (Offered alternate years.)

**820. Advanced Igneous Petrology**

Extensive readings and discussions of original sources and recent literature with reference to classical petrologic provinces. Application of thermodynamics and phase-rule chemistry to igneous petrogenesis. Mr. Bothner. Prerequisite: graduate standing and permission of instructor. 3 credits. (Offered alternate years.)

**821. Advanced Metamorphic Petrology**

Extensive readings and discussions of original sources and recent literature dealing with the facies concept, equilibrium reactions, reaction kinetics, and other chemical aspects of metamorphic petrogenesis. Mr. Bothner. Prerequisite: graduate standing and permission of instructor. 3 credits. (Offered alternate years.)

**841. Analytical Geochemistry**

Introduction to the theory, instrumentation, and applications of analytical methods in Geochemistry. Mr. Gaudette. Prerequisite: permission of the instructor. 3 credits. (Offered alternate years.)

**856. Estuarine and Marine Sedimentation**

The unique aspects of sedimentation in marine and brackish water environments will be discussed with special emphasis placed on the particulate matter and the factors that control its deposition. Deep sea marine sediment will be examined primarily for non-biogenic components. The course will include completion of a project and preparation of a report suitable for publication. Mr. Anderson. Prerequisite: Geology 501, Introduction to Oceanography, and a course in statistics. 3 credits.

**895, 896. Topics in Geology**

Advanced work on an individual or group basis under members of the graduate staff. Prerequisite: permission of department chairman and staff concerned. 1-4 credits. May be taken more than once. Sections of this course are the same as those listed under Geology 795.

**897, 898. Seminar in Contemporary Geology**

A review and discussion of recent geological literature. Required of graduate students in Geology. Staff. 1-3 credits.

## German and Russian

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**899. Geology Master's Thesis**  
6-10 credits.

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## German and Russian

Acting Chairman: *Marron C. Fort*

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PROFESSOR: Hermann W. Reske

ASSOCIATE PROFESSORS: Marron C. Fort, Helmut F. Pfanner

ASSISTANT PROFESSORS: Guenter Herr, James L. Sherman

The Department of German and Russian offers a program of graduate study in German leading to the degrees of Master of Arts and Master of Science in teaching.

To be admitted to graduate study, a student must have completed an undergraduate major in German comparable to that offered at the University of New Hampshire. It is expected that the student will have a superior command of spoken and written German and will be able to demonstrate his knowledge of a second modern foreign language.

To satisfy the requirements for the degree of Master of Science in Teaching, a candidate must complete 10 courses approved by the Department, including one seminar and two courses in Education. The candidate must also pass the departmental comprehensive examination which is based on the Master's reading list. This reading list, which covers the entire field of German literature from the beginnings to the present, is obtainable at the offices of the Department.

To satisfy the requirements for the degree of Master of Arts, the student must (a) successfully complete 10 courses including two seminars or (b) complete 8 courses successfully and write a master's thesis. The candidate must also pass the departmental comprehensive examination based upon the Master's reading list.

If the candidate chooses to write a thesis, he may not undertake work on it until he has passed the comprehensive examination. The thesis should be the result of independent investigation and be prepared in a form prescribed by the Department.

A student may do part of his graduate study at the University of Marburg. To this end he should consult with the Department Chairman.

Courses numbered 700-799 are for graduates and advanced undergraduates.

Courses numbered 800-899 are open only to graduate students. In rare instances, an undergraduate may be admitted with the permission of the instructor and the department chairman. Graduate students must take a minimum of three courses at the 800 level.

### **707, 708. Comparative Literature**

For 1970-71, a study of the European novel of the 20th century, taught by members of the faculty of the Departments of English, French and Italian, German and Russian, and Spanish and Classics. 4 credits.

### **726. German Culture and Civilization**

A survey of the historical, social, artistic, and folkloristic developments in German-speaking countries from the beginnings to the present. 4 credits.



**751/752. The Civilization of the Low Countries**

A survey of the literature, art, history, and social structure of the Netherlands and Flanders from the beginnings to the present. This course is conducted in Dutch and English. 3 credits.

**756. German Enlightenment Literature**

German literature from the end of the Baroque to the period of Storm and Stress with the emphasis on the works of Lessing and Wieland. 4 credits.

**757/758. The Age of Goethe**

The German literature of the Storm and Stress and the Classical Period; Wagner, Klinger, Lenz, Schiller, and Goethe. 4 credits.

**761. Kleist—Hölderlin—Jean Paul**

Outstanding authors outside the Romantic School. 3 credits.

**762. German Romanticism**

German Literature from 1780-1830. Critical analysis and interpretation of prose, drama, and poetry from Wackenroder to Eichendorff. 4 credits.

**771. German Literature of Biedermeier, Junges Deutschland, and Vormarz**

A study of the works of Grillparzer, Morike, Stifter, Heine, Buchner, and other writers of the post-Romantic period. 4 credits.

**772. The Age of Realism**

The outstanding prose and lyrics of Keller, Meyer, Storm, Fontane, and others. 4 credits.

**777/778. Bibliography and Advanced Stylistics**

A study of the methods of bibliographical research including a thorough grounding in the techniques of German stylistics. Students will prepare an extensive bibliography and submit frequent research papers. 4 credits.

**781. History and Development of the German Language**

The changes in the sounds, structure, and vocabulary of the German language from the earliest records to the present. 4 credits.

**783. Modern German Drama**

Critical readings and discussion of works by Hauptmann, Schnitzler, Hofmannsthal, Brecht, Dürrenmatt, and others. 4 credits.

**791. Methods of the Teaching of German**

A critical study of modern language teaching at all levels from the elementary school through college. The course emphasizes the use of the most modern equipment, including films, tapes, and other audio-visual aids. 4 credits.

**795-796. Special Studies in German Culture**

Directed studies in one of the following areas of German Culture:

- |  |                                |
|--|--------------------------------|
| 1. German Art  | 4. Studies in German Antiquity |
| 2. German Music                                      | 5. German Folklore             |
| 3. Geography of Germany,<br>Austria, and Switzerland | 6. The Third Reich             |

4 credits.

### **841/842. Old Icelandic**

An introduction to the Norse sagas and poetry as they are preserved in the literature of Medieval Iceland. Special attention is given to the poems of the Older Edda. 3 credits.

### **843. Introduction to Middle High German**

The phonology and grammar of Middle High German. The reading of selected texts. 3 credits.

### **844. Old High German**

A linguistic analysis of Old High German grammar, phonology, morphology, and syntax. Reading of selected texts with emphasis on dialectical distribution. 3 credits.

### **855. German Baroque Literature**

German literature between the Reformation and the Age of Enlightenment. 3 credits.

### **861. Modern German Prose**

Critical reading of selected prose works by Mann, Hesse, Kafka, Broch, and others. 3 credits.

### **862. German Post-War Literature**

Discussion of major writers and their works from 1945 to the present: Boll, Frisch, Dürrenmatt, Grass, Weiss, and others. 3 credits.

### **864. Modern German Poetry**

Analysis and interpretation of selected lyrical works by Rilke, George, Hofmannsthal, Benn, Trakl, and others. 3 credits.

### **879. The Phonology of German**

A contrastive analysis of the sounds of English and German. Phonetics, morphophonemics, and distinctive features. 3 credits.

### **880. The Structure of Modern German**

A grammatical analysis of modern German employing structural, tagmemic, and transformational models. 3 credits.

### **885/886. Graduate Studies Abroad**

A program of studies at the University of Marburg (West Germany) for students who have been admitted to the Graduate School of the University of New Hampshire. Interested students should consult with the Department Chairman.

### **887. Seminar in Germanic Linguistics**

An intensive study of a specific topic in Germanic philology involving the preparation of a research paper. 3 credits.

### **888. Seminar in German Literature**

An intensive study of a literary group or figure. 3 credits.

### **889. Seminar in German Literature**

An intensive study of a literary group or figure. 3 credits.

**895/896. Special Studies in Germanic Language and Literatures**

Examples of topics which may be selected are: (1) Runic Inscriptions, (2) Gothic, (3) Medieval Epics, (4) Medieval Drama, (5) Renaissance Drama, (6) Grimmshausen: *Simplicissimus*, (7) Medieval Dutch: *Van den Vos Reynaerde*, (8) Goethe: *Wilhelm Meister*, (9) German Exile literature, 1933-45, (10) Frisian Dialects, (11) Low German Realism: Groth, Brinckmann, Reuter, (12) Expressionism, (13) Radicalism in German literature, (14) Medieval Dutch and Low German Folksongs. 3 credits.

**899. Master's Thesis**

3 credits.

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**History (53)**

Chairman: *William R. Jones*

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PROFESSORS: H. Trevor Colbourn, William Greenleaf, Hans Heilbronner, Charles A. Jellison, David F. Long, Darrett B. Rutman

ASSOCIATE PROFESSORS: George E. Cunningham, Robert C. Gilmore, Marion E. James, William R. Jones, Douglas L. Wheeler

ASSISTANT PROFESSORS: Charles E. Clark, Thomas M. Kemnitz, Allen B. Linden, Robert M. Mennel, Marc L. Schwarz, John O. Voll

DIRECTOR OF GRADUATE STUDIES: Darrett B. Rutman

The Department of History offers programs leading to the degree of Master of Arts and Doctor of Philosophy. The Department considers that a substantial foundation in history is prerequisite to beginning work on the graduate level. Consequently it usually requires completion on an undergraduate level of the equivalent of a history major at this University (8 semester courses in history) and some preparation in other areas of the humanities and social sciences. The Department also recommends, although it does not absolutely require, that a beginning graduate student have some training in a foreign language. Applicants should submit aptitude and history scores on the Graduate Record Examinations. Applicants intending the Ph.D. degree should include with their applications a personal letter indicating their reason for and intentions in undertaking graduate study.

**Master of Arts**

The Master's degree may be undertaken as a terminal degree or as preparation for a Ph.D. program. A successful candidate shall complete with grades of P or better at least 8 semester courses in history numbered above 700, of which a minimum of 4 shall be numbered between 800 and 898. In addition, the candidate will complete a thesis satisfactory to his thesis committee. Upon the recommendation of the Department a student may substitute 2 additional semester course for the thesis. (The preparation of the thesis is considered to be the equivalent of 2 semester courses each bearing the designation History 899 for the purpose of meeting the general regulations of the Graduate School as stated earlier in this Bulletin.) The completed thesis must be submitted by April 1 of the year in which the degree is to be granted. A final examination is not required. Students intending a Ph.D. degree normally include as part of their work either or both of the following which they have not completed as undergraduates: Language training to the extent of

competence in one foreign language; and surveys of American and European historiography, equivalent of History 723 and 774.

### Doctor of Philosophy

The degree of Doctor of Philosophy is not essentially a course-related degree. It is awarded in recognition of high attainment and ability in history as shown by performance in qualifying examinations covering one major field of history with emphasis upon that subfield of specialization in which the student will prepare his dissertation, two subfields outside the major field, and a cognate field outside of history or a field of non-western history. At present dissertations are limited to the major field of American history with the subfields Early America (to *ca.* 1815) and Modern America (since *ca.* 1815). Prior to admission to a doctoral program the student is required to demonstrate competence in one foreign language; prior to admission to qualifying examinations he is required to demonstrate competence in a second language or a special research technique.

### Apprenticeship

The Department considers that graduate work in history, and particularly doctoral work, is professional training. All entering graduate students intending a Ph.D. are, consequently, required (and all others are urged) to participate on a continuing basis in History 801, Proseminar: History as a Profession. Moreover, the Department recognizes the dual concerns of the historian's life—research and teaching. All doctoral students, consequently, are expected to undertake teaching assistantships in the Department during a part of their residence. Participation in proseminar and as a teaching assistant constitutes an apprenticeship conjunctive with, but apart from, formal study.

A complete guide to the Department's graduate regulations and practices is available from its Director of Graduate Studies.

#### 703. The Colonial Period of American History

Anglo-America from the late sixteenth century to the mid-eighteenth century, encompassing a general and interpretative view of the development of an Anglo-American culture along the eastern seaboard of North America. Mr. Clark, Mr. Colbourn, Mr. Gilmore, Mr. Rutman. 4 credits.

#### 704. Sources and Methods of Colonial American History

An introduction to the materials and methodology of the historian of Anglo-America, structured around a series of problems underlying the interpretations considered in 703; specific approaches to these materials; and what historians have done with the materials. Mr. Rutman. Prerequisite: History 703 and (for graduate students) permission of the instructor. 4 credits.

#### 705, 706. America in the Eighteenth Century and the Revolution

American Colonial and Revolutionary history during the period from 1740 through the adoption of the Constitution and the establishment of Washington's first administration. Mr. Gilmore. 4 credits.

#### 711, 712. Nineteenth Century America

The historical factors, both domestic and international, involved in the development of the American Republic, its institutions and people, from the inception of the new nation in 1789 to the emergence of the United States as a world power in 1900. Mr. Jellison. 4 credits.

**715, 716. Twentieth Century America**

United States history since 1896, from the triumph of industrialism on the national scene to the emergence of America as a world power in the nuclear age. Political, economic, and diplomatic developments. Mr. Greenleaf. 4 credits.

**719, 720. The Foreign Relations of the United States**

Primarily the history of American diplomacy, with attention given to the non-diplomatic aspects of foreign relations. Mr. Long. 4 credits.

**721, 722. History of American Thought**

An examination of the ideas, considered in their social context, of significant American thinkers. First semester, 1600 to 1860. Second semester, 1860 to the present. Mr. Clark, Mr. Mennel. 4 credits.

**723. American Historiography**

The principal writings of American historians from the colonial period to the present time. Emphasis will be given to those works that pertain mainly to the American people and their immediate neighbors. Mr. Jellison. Prerequisite: permission of instructor. 4 credits.

**724. American Urban History**

The development of urban society in America from Colonial times to the present. Lectures will also explore the comparative histories of European and American cities. Mr. Mennel. 4 credits.

**725, 726. Afro-American History**

Basic historical problems, with reference to the economic, political, and social conditions of black Americans, from the early slave-trade period to recent radical confrontations and the Black Power movement. Mr. Cunningham. 4 credits.

**739, 740. Three Medieval Civilizations**

The demise of classical antiquity in the lands bordering the Mediterranean and the genesis and fruition of three new cultural traditions: the Latin Christian, the Islamic, and the Byzantine. Religious, literary, and scholarly survivals and innovations from 400 A.D. to 1400 A.D. Mr. Jones. 4 credits.

**743. Renaissance and Reformation**

The history of Europe during the fifteenth and sixteenth centuries with primary emphasis on the Italian Renaissance, the Protestant Reformation, and the emergence of the national state. 4 credits.

**747. The Age of Absolutism**

The theory and practice of absolutism from its origin in the seventeenth century to its apogee in enlightened despotism. 4 credits.

**749. The Age of Revolution**

Revolution as a socio-political phenomenon in its historical setting. Comparative approach to Puritan, American, and French revolutions with reference to contemporary movements. Mr. Gilmore. 4 credits.

**756. Twentieth Century Europe**

The background of World War I, the inter-war period, the rise of European totalitarianisms, World War II, and the attempts to solve the conflicts of modern society in the post World War II period. Mr. Heilbronner. 4 credits.

### **(759). History of Modern Spain and Portugal**

The Iberian states and their peoples from the coming of liberalism to the present. Why Iberian liberalism and liberal government failed to triumph will be a featured theme. Political and social change will be emphasized and imperial and intellectual movements. In the study of two modernizing countries with persistent traditions, influences of Western European thought and activity will be included. Mr. Wheeler. 4 credits.

### **761, 762. England in the Tudor and Stuart Periods**

An examination of the political, religious, socio-economic, and intellectual forces for change at work in England from the accession of Henry VII to the Revolution of 1688-89. Mr. Schwarz. 4 credits.

### **763, 764. History of Russia**

The development of the Russian state from its foundation to its present status as a world power. The course is designed to increase the understanding of the present in terms of the past. Political developments, foreign relations, and intellectual and ideological currents. Mr. Heilbronner. 4 credits.

### **767, 768. History of Germany**

Germany and the various German states from the Reformation to the Third Reich and the presently divided Germany. The course will emphasize the relationship and importance of Germany to the rest of Europe. Mr. Lentz. 4 credits.

### **771, 772. Modern England**

Emphasis will be placed on changes in the social and economic structure, and on political and intellectual changes. Mr. Kemnitz. 4 credits.

### **774. European Historiography**

The central concern of this course will be approaches to history and the writing of history. The works of major European historians will be the material discussed in the course. Mr. Kemnitz. Prerequisite: permission of the instructor. 4 credits.

### **777, 778. The Hellenistic-Roman World**

History of the Ancient World from the death of Alexander in 323 B.C. to the end of Constantine's reign in 337 A.D. Major political, economic, and social developments, and consideration of artistic, scientific, philosophical, and religious trends, with particular emphasis on the rise of Christianity and the transformation of the classical world. Miss James. 4 credits.

### **(781). History of Modern China, 1850-1950**

The modernization of China. The political, social, and cultural changes which have occurred in China from its early contacts with the West to the establishment of the Communist regime. Mr. Linden. 4 credits.

### **784. History of Southern Africa Since 1820**

The struggle for political and economic control in the only region of Africa where European groups remain in power. Special attention is given to the development of European hegemony. The course will trace the impact of European imperialism, European settler nationalism, African nationalism, racial conflict, economic competition and industrialization, Apartheid, and assimilation.

Included will be a discussion of official American policy in this region. Mr. Wheeler. 4 credits.

### 785. The Modern Middle East

A history of the Middle East from the eighteenth century to the present time, with special attention given to the problems created by modernization and reform of the traditional society, the conservative reaction to reform, the impact of nationalism, and the appearance of new ideologies. Mr. Voll. 4 credits.

### (787). Black Consciousness and Protest

A survey of the origins and cause of the rising consciousness and consequent activism of the peoples of Negro descent in the New World and in Africa from the early nineteenth century to the present. The course includes: lectures; discussions; and panels on protest literature, black nationalism, Pan-Negroism, Pan-Africanism, *negritude*, the Nation of Islam, and separatist religious sects in the Americas and Africa. The framework will be cross cultural and multi-disciplinary. Mr. Wheeler. 4 credits.

### (789). Seminar in the History of Science

Selected topics, conducted through special lectures, individual study, and oral and written reports. The subject will vary from year to year. This course is the same as Physical Science (789). *Cannot be used for credit in History without permission of the history department.* Mr. Schneer. Prerequisite: permission of adviser and instructor. 4 credits.

### 791. History-Education. Problems in the Teaching of High-School History and Other Social Studies

Bibliography and new interpretations of history; the social-studies curriculum, past and present; aims and objectives in the social studies; selection and organization of teaching material; teaching and testing techniques. Special emphasis on teaching American history and the problems of American democracy. Open to students who have satisfactorily completed History 503, 504; six credits in other history courses, exclusive of History 501, 502; six credits from American Government, Principles of Economics, or Principles of Sociology; and Principles and Problems of Teaching in the Secondary School. Mr. Draves. 4 credits.

### (793). World History

History from the perspective of the experience of the whole human community. The histories of separate areas will be examined in terms of their relationship to the general historical experience of man. Problems of interpretation, interrelationships, similarities, and differences in the development of the major traditions of civilization. Students will present oral and written reports as a basis for discussions. Mr. Voll. Prerequisite: permission of instructor. 4 credits.

### (797). Colloquia in History

Selected topics in American, European, and non-Western history. Staff. Prerequisite: permission of instructor. 4 credits.

## Graduate Readings and Seminars

Note that in any given semester any number of sections of a general seminar course (819 through 860) may be offered, the content and direction of a specific section depending upon the research interests of the faculty

member directing the section. General seminar and readings courses, and particular sections, can be repeated as the section content changes. A full description of the current direction and content of each section offered in a given semester is available shortly before the semester from the department's Director of Graduate Studies.

**(801). Proseminar: History as a Profession**

Entering graduate students intending the doctorate and all advanced graduate students serving as research, program, or teaching assistants in the department meet periodically to discuss the obligations and mechanics of the historian's profession, including teaching, scholarship, university and college structures, and the role of the faculty therein. Mr. Rutman and Mr. Voll. No credit.

**(819, 820). Seminar in Early American History**

(1) Mr. Clark (Social and Cultural), (2) Mr. Colbourn (Intellectual), (3) Mr. Gilmore (Revolution), (4) Mr. Rutman (Anglo-American Society). Prerequisite: permission of the instructor. 3 credits.

**(823, 824). Seminar in American National History**

(1) Mr. Cunningham (Afro-America), (2) Mr. Greenleaf (20th Century), (3) Mr. Jellison (19th Century and Biography), (4) Mr. Mennel (Social). Prerequisite: permission of instructor. 3 credits.

**(839, 840). Seminar in Medieval History**

(1) Mr. Jones (Ecclesiastical History). Prerequisite: permission of the instructor. 3 credits.

**(843, 844). Seminar in Early Modern European History**

Prerequisite: permission of the instructor. 3 credits.

**(855, 856). Readings in Modern European History**

(1) Mr. Heilbrunner (Modern Russia), (2) Mr. Lentz (Germany), (3) Mr. Wheeler (Spain and Portugal). Prerequisite: permission of the instructor. 3 credits.

**(859, 860). Seminar in English History**

(1) Mr. Kemnitz (19th Century), (2) Mr. Schwarz (Tudor-Stuart). Prerequisite: permission of the instructor. 3 credits.

**(895, 896). Tutorial Reading and Research in History**

(1) Early American History, (2) American National History, (3) Canada, (4) Latin America, (5) Medieval History, (6) Early Modern Europe, (7) Modern European History, (8) Ancient History, (9) Far East and India, (10) Near East and Africa, (11) European Historiography, (12) American Historiography, (13) Russia, (14) World History, (15) English History. Staff. Prerequisite: permission of instructor. 3 credits.

**(899). Master's Thesis**

**(999). Doctoral Research**



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## Home Economics (31)

Chairman: *Marjory A. Wybourn*

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PROFESSOR: Marjory A. Wybourn

ASSOCIATE PROFESSORS: Earl O. Goodman Jr., Mary Holder, Elizabeth M. Rand, James L. Spangenberg

Graduate work is offered leading to the degree of Master of Science in Home Economics, with major emphasis in areas which strengthen professional competence in family, community, and educational services.

Each student's program will be planned to achieve personal and professional objectives of the individual and be based on specific interests, ability, and undergraduate preparation. Selection of courses from the social sciences and other University departments will be encouraged.

Students admitted to the graduate program in Home Economics are expected to have had an undergraduate degree in Home Economics or a related field. If there are deficiencies in the undergraduate program, students may be admitted on condition that they complete specified prerequisites.

A candidate for a Master of Science degree in Home Economics is expected to fulfill the general requirements of the Graduate School and the following departmental requirements:

1. Home Economics—a minimum of 12 semester credits, including one course in each of the following two areas: management and decision-making in the family and family development.
2. A minimum of 9 semester credits selected from the liberal arts or other areas which support the major.
3. Research—a minimum of 4 semester credits, including Home Economics 897, Research Seminar, and Home Economics 898, Research Project, or Home Economics 899, Thesis.

### 707. Practicum with Children and Families

A planned, supervised experience with children or families at both participating and observing levels. The practicum is designed to increase the students' awareness and understanding of the ways human beings grow and behave and the dynamics of the family and community settings. Weekly class discussions will be combined with individual and small-group supervisory conferences. Students have the opportunity to choose a focus for their practicum from among the following: 1) young children—preschool program, 2) school-age children, 3) adolescents, 4) children and parents, and 5) low-income families—management experiences. Limited to Home Economics majors. Prerequisite: Home Economics major and permission of department. One or more semesters, 2 or 4 credits, maximum of 6 credits in one area.

### 715. Clothing in Relation to Human Behavior

The analysis of research and theory in the social-psychological aspects of clothing. An exploration and study of clothing behavior of individuals and groups. Special emphasis given to stages of the life cycle, development of the self, and the phenomenon of fashion. 4 credits.

### **725. Preschool Programs**

A study of the organization and operation of programs for young children. Theoretical knowledge about children and educational techniques will be related to the curriculum, facilities, and administration in a variety of group programs for young children. Field trips will be planned. Prerequisite: Home Economics 627 or equivalent. Limited to Home Economics majors, or permission of instructor. 4 credits.

### **754. Personal and Family Finance**

A study of major financial alternatives available to families during the various stages of the family life cycle. 4 credits.

### **774. Nutrition and Disease**

Application of the principles of normal nutrition to clinical problems, with a description of altered nutrient requirements in human disease. Diet therapy as an applied aspect of clinical nutrition is considered. A practicum in a field situation will be a part of the experience. Prerequisite: Home Economics 573, Human Nutrition, or equivalent. 4 credits.

### **776. Nutrition—A World View**

Study of the major nutritional problems facing the world today. Consideration of protein—calorie malnutrition, obesity, nutritional status of adolescents, and special nutritional problems of pregnancy, infancy, childhood, and the aging. An exploration of concepts and methodologies for nutrition education. Prerequisite: Home Economics 573, Human Nutrition, or equivalent. 4 credits.

### **786. Dynamics of Family Change**

The major focus of this course is an examination of the theories and supporting research of the intervention techniques used to affect changes in family behavior. The secondary focus is the student's examination of his interaction processes and their effect on intervention efforts. Prerequisite: Home Economics 683, Family Relations and Psychology 545, Clinical Approaches to Human Behavior, or permission of instructor. 4 credits.

### **793. Sex Education in Home, School, and Community**

An exploration of human sexuality and of programs, materials, and methods for sex education in home, school and community. Issues, community mores, goals, and values will be examined. Planned for school personnel, parents, and others working with children, youth, and families. 4 credits.

### **883. Human Sexual Behavior**

An exploration of contemporary opinion and research on human sexual behavior and development. The implications for personal and social welfare and education will be examined in light of available research and other scholarly studies. 4 credits.

### **892. Methods in Family Relation Education**

A study of the methods and materials used in family relations education in high schools, colleges, churches, and social agencies. The methods will be applied through role play and field experience. The course assumes mastery of the basic principles of family relations, human development, and theories of intervention. 4 credits.

### 895. Seminar and Special Problems

The seminars are open to graduate students with sufficient background for in-depth study in any of the following areas: 1) clothing and textiles, 2) consumer education, 3) family relations, 4) food and nutrition, 5) home economics education, 6) management and family finance, and 7) human development. The student will contribute to a selective review and critical evaluation of the research and current literature and an examination of issues and trends. Independent projects may be a part of the experience. These seminars will not be scheduled every semester. One or more semesters, maximum of 4 credits in one area, 2 to 4 credits.

### 897. Research Seminar

Survey, evaluation, and use of research in the field of home economics. An introduction to methods and techniques used in defining a problem for study, collecting data, analyzing, and writing a report. 2 credits.

### 898. Research Project

A study or project which may be selected in lieu of a thesis. To be taken concurrently or following Home Economics 897. 2-4 credits.

### 899. Thesis

6 credits.

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## Interdisciplinary Options and Programs

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### Soil and Water Chemistry Option

The chemist can contribute much to the advancement of many scientific disciplines through the application of the principles of chemistry to research problems in these other disciplines. The Departments of Chemistry and Soil and Water Science have instituted an option in the Doctor of Philosophy program in Chemistry which enables the graduate student to apply his chemistry background to research problems of mutual interest to the two departments. A student entering this option must meet the entrance requirements for the Doctor of Philosophy program in Chemistry. So that the student may obtain a background in Soil and Water Science, he will be permitted to substitute graduate level courses in Soil and Water Science for certain courses in Chemistry. His dissertation will be on a basic problem of interest to faculty members in both departments. For further information, write to either the Department of Soil and Water Science or to the Department of Chemistry.

### Chemical Physics Option

Doctor of Philosophy candidates in Chemistry may elect to enter the Chemical Physics program, an interdisciplinary program offered jointly with the Department of Physics. In this option the doctoral student, with the advice of his guidance committee, elects courses in chemistry and physics (or, in some cases, mathematics), write his dissertation on a research problem (experimental, theoretical, or both) appropriate to interdisciplinary treatment and receives the doctorate in either Chemistry or Physics. In addition, each candidate must satisfy certain other requirements of the department in which the degree is granted. Ordinarily, students choosing the Chemical Physics option are expected to have undergraduate degrees in chem-

## Mathematics

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istry, physics, or mathematics and reasonably strong backgrounds in the other two disciplines.

### Zoology Option

Faculty from departments related to Zoology, such as Animal Sciences and Entomology, may direct master's and doctoral dissertations.

### Marine Science—Oceanography

The University of New Hampshire has long had an interest in marine science. The location of the University on the Great Bay and its tidal estuaries provides a natural laboratory for marine sciences including oceanography and marine-oriented biochemistry, botany, geology, microbiology, and zoology. The recently constructed Jackson Estuarine Laboratory and the newly acquired research vessel, R/V "Jere A. Chase," give evidence of the heightened interest in marine studies. A prospective graduate student who wishes to emphasize marine science or oceanography in his graduate work may do so by selecting courses in the departments of Biochemistry, Botany, Geology, Microbiology, or Zoology. For further information, write to the Office of Marine Science and Technology, Kingsbury Hall.

### Ocean Engineering—EDAL

The Engineering Design and Analysis Laboratory is an interdisciplinary faculty group mainly from the College of Technology. This group, early in its history, chose to make ocean-oriented engineering its principal, but not exclusive, interest. The stated purpose of EDAL is to involve faculty and students in realistic and challenging engineering projects. Projects thus far accomplished have made EDAL-associated faculty and EDAL-associated graduate students participants in advanced ocean-oriented engineering. Prospective graduate students who desire information regarding EDAL activities should write to the Office of Marine Science and Technology, Kingsbury Hall.

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## Mathematics (84)

Chairman: *M. Evans Munroe*

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PROFESSORS: Richard H. Balomenos, Edward H. Batho, Arthur H. Copeland, A. Robb Jacoby, Richard E. Johnson, Shan S. Kuo, M. Evans Munroe, James Radlow, Shepley L. Ross, Robert J. Silverman

ASSOCIATE PROFESSORS: Homer F. Bechtell, William E. Bonniece, David M. Burton, Eric A. Nordgren

ASSISTANT PROFESSORS: Albert B. Bennett, Berrien Moore, III, Samuel D. Shore, Christopher C. White, William G. Witthoft

The Mathematics Department offers courses leading to three graduate degrees: Master of Science for Teachers, Master of Science, and Doctor of Philosophy.

### Master of Science for Teachers

Admission requirements: Completion of all requirements for secondary school teacher certification in Mathematics. Degree requirements: (1) Ten semester courses approved by the department. These will normally be taken from the courses

numbered 801-829 and will usually include the six courses numbered 803-808. (2) A comprehensive examination based primarily on material in courses 803-808. It is not possible to work full time during the academic year toward the Master of Science for Teachers degree. The courses in this program are offered primarily in summer institutes.

### **Master of Science**

Admission requirements: Mathematics 620, 763, or 767-768 or the equivalent of one of these sequences elsewhere. Preference will be given to applicants who have completed both these sequences. Degree requirements: Ten semester courses approved by the department. These must be chosen from courses numbered 701-799 or 830-899. At least six of the ten must be from the 830-899 group.

### **Doctor of Philosophy**

Admission requirements: same as for Master of Science. Degree requirements: (1) Course work as prescribed by the Department. This will normally include all the courses numbered 833-842 together with several courses numbered 860-898. (2) Proficiency in reading mathematical literature in two of the three languages: French, German, and Russian. (3) Experience in teaching, equivalent to at least one-half time for one year. (4) Qualifying examination. This is in two parts. The first part (written) must be taken after three semesters in residence. It will cover basic topics in graduate level mathematics. The second part (oral) is normally taken in the third year and covers more advanced topics. (5) Thesis. This is the principal item in the doctoral program. New and original results will be required. At present, thesis work is available in the fields of algebra, analysis, and topology.

Courses numbered between 600 and 699 may be taken for graduate credit by non-majors only.

#### **635. Partial Differential Equations**

Sturm-Liouville problems; exact and approximate determination of characteristic values and functions; Fourier series and Fourier integrals; solution of boundary value problems for partial differential equations by series and integrals; classification, cononical forms, and basic concepts of second order; linear partial differential equations; elliptic, parabolic, and hyperbolic equations. Prerequisite: Mathematics 527, 528, (Differential Equations, Multidimensional Calculus). 4 credits.

#### **640. Linear Algebra**

Vector spaces, matrix algebra, bases and linear transformations, determinants, inner products, quadratic forms. Prerequisite: Mathematics 426. 4 credits.

#### **656. Introduction to Number Theory**

Unique factorization, linear and quadratic congruences, quadratic reciprocity law, arithmetic functions, quadratic forms, and introduction to algebraic numbers. Prerequisite: Mathematics 640. 4 credits.

#### **657. Geometry I**

Fundamental properties of Euclidean geometry from an advanced standpoint. Prerequisite: Mathematics 640. 4 credits.

### **658. Geometry II**

Systems of postulates of various geometries, geometric invariants, synthetic and analytic projective geometry, introduction to non-Euclidean geometry. Prerequisite: Mathematics 640. 4 credits.

### **682. Non-Linear Differential Equations**

Phase plane analysis of linear and non-linear autonomous systems; critical points; limit cycles; periodic solutions; approximate methods for second order, non-linear, ordinary differential equations; stability and asymptotic behavior of solutions of linear and non-linear equations. Prerequisite: Mathematics 527. 4 credits.

A maximum of four of the following courses may be applied to the degree of Master of Science in Mathematics.

### **710. Advanced Programming Systems**

An introduction to computer systems organization, machine language, and digital representation of data. Software studies are compilers, assemblers, loaders, system utility program, and macros. All programming will be done in Basic Assembly Language on the IBM 360. Prerequisite: Mathematics 410 or equivalent. 4 credits.

### **735. Probability**

Sample spaces (discrete and continuous); random variables; conditional probability; moments; binomial, Poisson and normal distributions; limit theorems for sums of random variables. Prerequisite: Mathematics 528. 4 credits.

### **736. Statistics**

Sampling theory, estimation of parameters, testing of hypotheses, non-parametric methods. Prerequisite: Mathematics 735. 4 credits.

### **753-754. Numerical Methods and Computers**

This course is oriented toward the use of numerical analysis on digital computers (with laboratory). Computer organization, algorithmic languages and compilers, solution of polynomial and transcendental equations, numerical solutions of differential equations, linear systems of equations, eigenvalues and eigenvectors, polynomial interpolation, quadrature, curve fitting, discussion of errors, systems simulations, and mathematical optimization techniques. Selected algorithms will be programmed for solution on high-speed computers in the Computation Center. Prerequisite: 753—Mathematics 410 and 426, 754—Mathematics 410 and 527. 4 credits.

### **763-764. Abstract Algebra**

Groups, rings, integral domains, fields, and linear algebra. Prerequisite: Mathematics 640. 4 credits.

### **767-768. Real Analysis**

Topology of the real line, metric spaces, topology of Euclidean spaces, limits, sequences and series, continuity, differentiation, integration, uniformity of limit operations, equicontinuity, function spaces, inverse and implicit function theorems. Prerequisite: Mathematics 528. 4 credits.

**776. Logic**

Development of formal mathematics. Discussion within that system of formal systems. Consistency, completeness, decidability. Prerequisite: consent of the instructor. 4 credits.

**780. Theory of Ordinary Differential Equations**

Fundamental existence and uniqueness theorems; linear systems and higher order linear equations; Wronskian theory; classical Sturm Theorem and generalizations; boundary value problems for second order linear equations. Prerequisite: Mathematics 527, 640, and 767. 4 credits.

**784. Topology**

Basic topological notions, connectedness, compactness, metrizability, with special emphasis on the real line and plane. Prerequisite: Mathematics 767. 4 credits.

**788. Complex Analysis**

Complex functions, sequences, limits, differentiability and Cauchy-Reimann equations, elementary functions, Cauchy's theorem and formula, Taylor's and Laurent's series, residues, and conformal mapping. Prerequisite: Mathematics 528. 4 credits.

**795. Calculus on Manifolds**

Differentiable manifolds; differential forms; exterior and Grassman algebras; integration of differential forms; Stokes theorem; closed and exact differential forms. Prerequisite: Mathematics 640 and 767. 4 credits.

The following courses may be applied to the degree of Master of Science for Teachers in Mathematics and to no other graduate degree in Mathematics.

**801-802. Fundamental Concepts of Mathematics for Teachers**

An introduction to the most fundamental concepts of analysis, geometry, and algebra. Basic elements of set theory; a survey of the real and complex number systems; the integers and the concept of an integral domain; introduction to groups; geometries, Euclidean and non-Euclidean; functions, sequences, and the limit concept; the derivative and the differentiation of algebraic functions. 3 credits.

**803-804. Higher Algebra for Teachers**

The integers, integral domains, and topics from number theory; equivalent relations and congruences; real numbers, complex numbers, and fields; polynomials; group theory; elements of matrix theory; vectors and vector spaces; rings; Boolean algebra. 3 credits.

**805-806. Higher Geometry for Teachers**

Systems of postulates of various geometries; geometric invariants; synthetic and analytic projective geometry; an introduction to non-Euclidean geometry; and topology. 3 credits.

**807-808. Higher Analysis for Teachers**

The real number system; variables, functions and limits; elements of set theory; numerical sequences and series; continuity; the derivative and the Riemann integral; maxima and minima. 3 credits.

**809. Probability and Statistics for Teachers**

Permutations and combinations; finite sample spaces; random variables; binomial distributions; statistical applications. 3 credits.

**811. Computers and Their Uses**

Computing machines and modern numerical methods. Each student will have an opportunity to make use of the University computer. 3 credits.

**814. Theory of Numbers for Teachers**

Fundamental concepts of elementary topology; network and map problems; sets, spaces, and transformations. 3 credits.

**816. Theory of Numbers for Teachers**

Divisibility and primes; congruences; quadratic reciprocity; number theoretic functions; Diophantine equations; Farey fractions; algebraic numbers. 3 credits.

**817. Theory of Sets and Elementary Logic**

An introduction. 3 credits.

**819. The Real Number System**

A postulational approach. Brief discussion of algebraic structures. Introduction to the sequences, limits, and continuity. 3 credits.

**820. History of Mathematics**

A problem-study approach to mathematical problems and solutions from the period of Greek mathematics until the 1950's will be used to present the history of mathematics. 3 credits.

**821. A Modern Approach to Geometry**

The foundations and development of Euclidean geometry, with emphasis on the recent School Mathematics Study Group's recommendations in the field of high school geometry. 3 credits.

**825. Internship**

Experience under the direction of a master teacher in teaching university level mathematics to superior high school students. This work will be done in the Advanced Studies Program at St. Paul's School, Concord, New Hampshire. 6 credits.

**826. Selected Topics in Algebra**

Topics selected to supplement the teacher's previous training in algebra, chosen from the following: linear algebra, vector spaces, groups, rings and ideals, and fields. 3 credits.

**827. Selected Topics in Geometry**

Topics selected to supplement the teacher's previous training in algebra, chosen from among the following: analytic projective geometry, non-Euclidean geometry, transformation theory, elementary metric differential geometry, topology. 3 credits.

**828. Selected Topics in Analysis**

Topics selected to supplement the teacher's previous training in analysis, chosen from among the following: sequences and series of real functions, Riemann integration, partial differentiation, complex functions, differential equations. 3 credits.



**829. Directed Reading**

A directed reading project on a selected topic in mathematics chosen to supplement the teacher's previous institute courses. A written examination will be required. 3 credits.

The following are the basic courses for both the Master of Science and Doctor of Philosophy Degrees in Mathematics

**831. Set Theory**

Foundations of the theory of sets; ordinal and cardinal numbers; Zorn's lemma; applications. 3 credits.

**833-834. Algebra**

Groups; rings; modules, fields; linear algebra. 3 credits.

**835-836. Real Analysis**

Outer measures and measures; Lebesgue integrals; convergence theorems; Banach spaces; representation of linear functionals; weak and weak\* topologies. 3 credits.

**837-838. Complex Analysis**

Complex variables and functions; analytic functions; complex integration; series, products; conformal mapping; analytic continuation and Riemann surfaces. 3 credits.

**839-840. General Topology**

Topological spaces; nets and filters; product and quotient spaces; embedding and metrization; compact spaces; uniform spaces; homotopy and fundamental group; covering spaces and fibrations. 3 credits.

**841-842. Algebraic Topology**

Chain complexes; homology of simplicial complexes; singular homology and cohomology; axiomatic homology; cup and cap products; topological manifolds; sheaves. 3 credits.

**851-852. Differential Equations**

Ordinary differential equations; existence theory; linear equations; Sturm-Liouville theory; non-linear autonomous systems; Poincare-Bendixson theory; partial differential equations; second order linear equations; initial value problems; hyperbolic equations; the Dirichlet problem. 3 credits.

**855-856. Applied Mathematics**

Calculus of variations, integral equations; operator theory; distributions; Hilbert spaces. 3 credits.

The following are advanced courses primarily for Doctor of Philosophy candidates, though they may be elected by qualified Master of Science candidates. In each of these the content will vary from year to year. Thus, with permission of the instructor, each of these courses may be taken more than once for credits, even concurrently. Normally, the content will be chosen from among the topics listed.

**861, 862. Topics in Algebra**

Algebraic number theory; algebraic geometry; ring theory; theory of modules; group theory; non-associative algebras. 3 credits.

## Mechanical Engineering

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### 863, 864. Topics in Analysis

Measure theory; calculus of variations; integral equations; boundary-value problems; orthogonal series; theory of approximation; analytic number theory; Riemann surfaces. 3 credits.

### 865, 866. Topics in Topology

Algebraic topology; theory of sheaves; dimension theory; Riemann surfaces; homotopy theory. 3 credits.

### 867, 868. Topics in Geometry

Convexity; projective geometry; differential geometry; tensor analysis. 3 credits.

### 869, 870. Topics in Topological and Algebraic Analysis

Rings of functions; linear topological spaces; topological algebras; Hilbert spaces; rings of operators; topological groups; Lie groups; harmonic analysis. 3 credits.

### 871, 872. Topics in Differential Equations

Boundary value problems; asymptotic behavior and stability theory; non-linear equations; dynamic systems; classical theory of partial differential equations; functional analysis and partial differential equations. 3 credits.

### 873, 874. Topics in Applied Mathematics

Linear and dynamic programming; differential equations; special functions. 3 credits.

### 875, 876. Topics in Probability and Statistics

Stochastic processes. 3 credits.

### 898. Reading Courses

Offered in the following areas: (a) Algebra, (b) Analysis, (c) Topology, (d) Geometry, (e) Topological and Algebraic Analysis, (f) Differential Equations, (g) Applied Mathematics, (h) Probability and Statistics. 3-6 credits.

### 999. Doctor of Philosophy Thesis

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## Mechanical Engineering (85)

**Chairman:** *Robert W. Corell*

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**PROFESSORS:** Robert W. Corell, Godfrey H. Savage, Charles K. Taft, Asim Yildiz

**ASSOCIATE PROFESSORS:** E. Eugene Allmendinger, Victor D. Azzi, Frederick G. Hochgraf, William Mosberg, Douglas M. Norris Jr., Russell L. Valentine

**ADJUNCT ASSOCIATE PROFESSOR:** Wayne M. Beasley

**ASSISTANT PROFESSORS:** Robert W. Alperi, David E. Limbert, John A. Wilson

The Mechanical Engineering Department offers programs of study, from the viewpoint both of the engineering sciences and of engineering design, in mechanics, materials science, automatic control, and the thermal sciences leading to the degree of Master of Science in Mechanical Engineering. The programs provide the background required for careers in research, engineering design or teaching, or for further graduate study.

To be admitted to graduate study in Mechanical Engineering, a student should have completed work equivalent to that required at the University of New Hampshire for a Bachelor of Science degree in his field.

A candidate for the degree of Master of Science shall satisfy the requirements of either a thesis plan or a project plan. The thesis plan requires 24 semester hours of course work in addition to Mechanical Engineering 899, Master's Thesis; the project plan requires 30 semester hours of course work in addition to Mechanical Engineering 892, Master's Project. Individuals with special qualifications may petition the Department to be excused from the project requirement. An oral examination covering the candidate's graduate work will be given whether or not a thesis is presented.

Students interested in the Engineering Ph.D. program should consult with the College of Technology for further information.

Students completing degree requirements through the University Extension Service must be admitted to the Graduate School and have their programs approved by the Department.

No more than two graduate courses taken prior to admission to the Graduate School may be applied to the Master's degree. Courses numbered between 600 and 699 may be taken for graduate credit by non-majors only.

Permission of the instructor and consent of the adviser is required for enrollment in all Mechanical Engineering graduate courses.

### **701. Macroscopic Thermodynamics**

A continuation of the study of thermodynamic principles using an analytical approach consistent with that of Gibbs and Caratheodory. 4 credits.

### **702. Statistical Thermodynamics**

An introduction to statistical thermodynamics. 4 credits.

### **703. Heat Transfer**

Analysis of heat transfer phenomena; steady-state and transient conduction, radiation, and convection; engineering applications. 4 credits.

### **704. Experimental Heat Transfer**

Experimental methods in the study and solution of heat transfer problems, including a critical comparison with analytical and other methods. Literature surveys and written and oral presentation of results will be emphasized. 4 credits.

### **707. Analytical Fluid Dynamics**

An analytical study of the dynamic behavior of fluids. Topics include potential flow, development of the Navier-Stokes equations, turbulence, and boundary layer theory. 4 credits.

### **708. Gas Dynamics**

Basic equations of motion of one-dimensional, subsonic and supersonic flows of compressible, ideal fluids. Wave phenomena. Rankine-Hugoniot relations. Linear approach to two-dimensional flow problems. 4 credits.

### **715. Internal Combustion Engines**

Application of basic and engineering science to the engineering problems of spark and compression ignition engines; design, management, and reporting of experimental studies. 4 credits.

### **716. Propulsion Systems**

Application of basic engineering sciences to the engineering problems of propulsion systems. 4 credits.

### **723. Advanced Dynamics**

Classical mechanics with an orientation to contemporary engineering applications. Review of particle dynamics. Hamilton's principle and the Lagrange equations. Kinematics and dynamics of rigid bodies, gyroscopic effects in machinery and space structures. 4 credits.

### **724. Introduction to Vibrations**

The theory of discrete vibrating systems is treated in depth. Review of linear system concepts and detailed treatment of the single degree of freedom system with general excitation. Matrix theory and eigen-value problems. Many degrees of freedom, normal mode theory for free and forced vibration. Numerical methods. Introduction to continuous systems. Applications are made both to structural and mechanical systems. 4 credits.

### **726. Experimental Mechanics**

Experimental methods and their underlying theoretical bases are developed and applied to the measurement of stress, strain, and motion. 4 credits.

### **727. Advanced Mechanics of Solids**

Advanced topics in the mechanics of solids are treated in depth; beams on elastic foundation, curved bars, inelastic behavior, instability, introduction to thin plates and shells, introduction to elasticity, energy methods, and numerical methods. 4 credits.

### **730. Mechanical Behavior of Materials**

The elastic and inelastic behavior of materials, both organic and inorganic, is studied from a point of view of micromechanics and macromechanics. Concepts of stress, strain, and constitutive relations are reviewed and related to recent developments in dislocation theory and other phenomena on the atomic scale and to continuum mechanics on the macroscopic scale. Mechanical behavior including elasticity, plasticity, viscoelasticity, creep, fracture, and damping will be treated. Anisotropic and heterogeneous materials such as composite materials will be studied in detail. 4 credits.

### **741. Control of Physical Systems**

Theory and methods for modeling and evaluating fluidic, hydraulic, and pneumatic control systems. 4 credits.

### **751. Naval Architecture**

Hydrodynamic resistances of surface ships and submerged bodies; model testing theory; powering and propellers; use of Standard Series tests; introduction to ship motion, control steering, and rudders; concepts of ship design; computer application to problems. 4 credits.

### **761. Crystalline Solids**

Theoretical and experimental studies of the structure of crystalline solids using X-ray diffraction techniques. 4 credits.

### **763. Microstructure of Solids**

Theoretical and experimental studies of the microstructure of solids using optical and electron microscopy. 4 credits.

### **781. Mathematical Methods in Engineering Science I**

Mathematical methods in engineering sciences are discussed, including methods for solution of discrete and continuous systems. Course includes a review of calculus, linear algebra, complex numbers, Fourier series, differential and partial differential equations with examples from acoustics, vibration theory, hydrodynamics, elasticity, solid mechanics, transport theory, and particle mechanics. 4 credits.

### **793 a-d and 794 a-d. Special Topics in Engineering**

Course numbers refer to topics in a) thermodynamics, b) mechanics, c) engineering design, and d) materials respectively. Content of these courses may vary from year to year. 2-4 credits.

### **795 a-d. Independent Study**

2-4 credits.

### **796 a-d. Independent Study**

2-4 credits.

### **801. Irreversible Thermodynamics**

Non-equilibrium thermodynamics from the viewpoint of fluctuation theory. The Onsager reciprocal relations. Prerequisite: Mechanical Engineering 701. 4 credits.

### **803. Conduction Heat Transfer**

Heat conduction equation; temperature fields and the heat flux vector; analytical solution of the conduction equation in several variables; initial and boundary value problems; numerical methods of solution. 4 credits.

### **804. Radiation Heat Transfer**

The fundamentals of radiant heat transfer. Development and solution of the wave equation for electromagnetic radiation. Analysis of Planck's law of radiation and earlier theories. Methods of solution of radiant interchange in real systems with and without absorbing media. 4 credits.

### **806. Convection Heat Transfer**

An analytical study of heat transfer to laminar and turbulent boundary layers of compressible and incompressible fluids. Basic differential equations governing the heat transfer are derived and analytical solutions are obtained where possible and checked with experimental results. 4 credits.

### **807. Compressible Fluid Flow**

General equations of motion for real and ideal compressible fluid flow including boundary layer equations; methods of solution. Prerequisite: Mechanical Engineering 707 or 708, Mathematics 630. 4 credits.

### **808. Theoretical Aero/Hydro-Mechanics**

The mathematical development of the equations of frictionless fluid flow using both tensor notation and various coordinate systems. Conformal mapping; Blasius Theorem; Joukowski Hypothesis; flow around airfoils. Schwartz Christoffel theorem and vortex motion. 4 credits.

### **822. Continuum Mechanics**

Conservation laws for gases, liquids, and solids in a continuum are developed starting from Liouville and Boltzmann equations. Passage from a discrete system to a continuum is discussed. Constitutive equations for viscoelastic, thermoelastic and non-linear gas, liquid, and elastic fields. General discussion of rheological behavior. Causality conditions for continuum fields. Examples for solids, liquids, and gases and biomechanics. Introduction to phenomenological Lagrangian theories. 4 credits.

### **824. Vibrations of Continuous Media**

Classical and numerical methods are employed to study the vibration of continuous elements and structures. Topics considered are axial and torsional vibration of rods, transverse vibration of beams and thin plates, wave propagation, and vibration of simple structures. 4 credits.

### **826. Theory of Elasticity**

The analysis of stress and deformation in elastic solids; conservation laws for elastic media; stress and strain relations by continuous functions; Airy stress functions, elastodynamic fields, inhomogeneous, anisotropic wave equations; wave propagation and stress concentration problems; generalizations to thermoelasticity and viscoelastic fields. Complex variable techniques will be used. 4 credits.

### **827. Theory of Plasticity**

Analysis of stress and deformation in inelastic solids; general development of stress invariants, variational principles, constitutive relations, and yield and loading functions. Special emphasis on ideal plasticity, strain-hardening, creep, limit analysis, and limit design. 4 credits.

### **829. Theory of Plates and Shells**

Theory of elasticity developed for plates and shells; conservation laws for elastic media; stress and strain relations by continuous functions; Airy stress functions; stress and strain relations in curvilinear coordinates; thin and thick plate and shell theories; vibration of spherical, cylindrical, and conical shells and plates. 4 credits.

### **842. Discontinuous Control**

The analysis and synthesis of feedback control systems operating on quantized information; compensation and performance improvement methods which use the quantized nature of the information are also developed. 4 credits.

### **860. Physical Metallurgy**

Introduction to the electron theory of materials; entropy and free energy concepts of the solid state; diffusion in metals; nature and kinetics of selected solid-state reactions. 4 credits.

### **866. Physical Ceramics**

Characteristics of crystalline and noncrystalline ceramic solids; defect structures; diffusion in ceramic materials; nucleation, crystal growth, and solid-state reactions; kinetics of grain growth, sintering, and vitrification. 4 credits.

### **882. Mathematical Methods in Engineering Science II**

This course is a continuation of ME 781 which is a prerequisite. Topics treated include complex variable techniques, integral transform techniques for the

solution of differential and partial differential equations, Green's functions, Wiener-Hopf techniques, variational techniques. Stochastic problems with application to random vibration, statistical control theory, turbulence, heat conduction and fluctuation phenomena in solids, transport theory, gases, and liquids. Topics may vary from year to year. 4 credits.

**883. Tensor Analysis and Differential Geometry**

Mathematical groundwork for applied group theory, transformation groups, affine groups and affine geometry. Coordinate transformations and point transformations. Affinors, tensors, and their algebraic properties. Invariant differential operators. Lie derivative, holonomic and anholonomic coordinate systems. Curvature tensor, Bianchi identity, tensor densities. Green's theorem, Green's functions, potential functions. Pfaff's problem. 4 credits.

**890 a-d and 891 a-d. Special Topics in Engineering**

Course numbers refer to topics in thermodynamics, mechanics, engineering design, and materials respectively. Content of these courses may vary from year to year. 2-4 credits.

**892. Master's Project**

The student will work with a faculty member on a well defined research and/or design problems. A written report and seminar will be presented. 4 credits.

**895 a-d and 896 a-d. Graduate Independent Study**

Investigation of graduate level problems or areas germane to mechanical engineering. 1-4 credits.

**899. Master's Thesis**

6-10 credits.

For additional courses, see listing under Technology, page 151.

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## **Microbiology (47)**

Acting Chairman: *Theodore G. Metcalf*

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**PROFESSORS:** William R. Chesbro, Galen E. Jones, Theodore G. Metcalf, Lawrence W. Slanetz

**ASSISTANT PROFESSOR:** Fred T. Hickson

Students admitted to graduate study in Microbiology are expected to have had adequate preparation in the biological and physical sciences and in the basic courses in Microbiology. The candidate for the Master of Science degree will be required to complete a thesis and pass an examination covering his graduate courses and thesis.

Candidates for the Doctor of Philosophy degree must demonstrate proficiency in reading microbiological literature in one foreign language, usually French or German, must demonstrate to the doctoral committee a broad, basic knowledge of the field of Microbiology, and must complete a dissertation on some original research in Microbiology.

**701. Advanced Microbiology**

The growth, nutrition, and metabolism of microorganisms; consideration of cell structure and localization of function; aspects of genetic and nongenetic regu-

lation of metabolism; study of the influences of chemical and physical factors of the environment upon microorganisms. Mr. Chesbro. Prerequisite: Microbiology 503. 2 lectures; 1 laboratory; 4 credits.

### 702. Pathogenic Microbiology

The morphological, cultural, biochemical, serological, and pathogenic characteristics of microorganisms causing human and animal diseases. Mr. Metcalf. Prerequisite: Microbiology 503. 2 lectures; 2 laboratories; 4 credits.

### 705. Immunology and Serology

The defensive elements possessed by man and animals which serve to protect them from infectious microorganisms. The principles of serological techniques used in the recognition and identification of biological materials including microorganisms. The preparation of vaccines and the production of antisera in animals. Mr. Metcalf. Prerequisite: Microbiology 702. 2 lectures; 2 laboratories; 4 credits.

### 706. Virology

The animal and plant viruses, including bacteriophages and the rickettsiae; a consideration of techniques for the propagation and recognition of animal viruses; the interactions between virus and host cell; and the application to problems of plant or animal infections caused by viruses. Mr. Metcalf. Prerequisite: Microbiology 702. 1 lecture; 3 laboratories; 4 credits.

### 707. Marine Microbiology

Characterization of microbes in the sea as to taxonomy, physiology, ecology, and transformations of carbon, nitrogen, sulfur, and phosphorous; methods of sampling and enumeration; biogeochemistry; properties of sea water and the marine environment. Parallels to soil microbiology will be drawn. Mr. Jones. Prerequisite: Microbiology 503 and Biochemistry 751. 2 lectures; 1 laboratory; 4 credits.

### 795, 796. Problems in Microbiology

Special problems, depending upon the training and desire of the student. Elective only upon consultation. Staff. Credits to be arranged.

### 800. Systematic Bacteriology

Procedures and methods for the classification of bacteria; review of modern systems of classification. Mr. Slanetz. Prerequisite: one year of microbiology. 2 lectures; 1 laboratory; 3 credits.

### 802. Microbial Physiology

Microbial physiology is the study of the means by which microorganisms survive. It deals with the effects of nutritional, chemical, and physical factors on microbial growth, the generation of activated metabolites during catabolism; and the use of these metabolites for the synthesis of macromolecules, the non-genetic mechanisms directing and regulating cellular metabolism; the biochemical cytology of the microbial cell; and with evolutionary and ecological relationships among microbial species. Mr. Chtsbro. Prerequisite: a course in general biochemistry (may *not* be taken concurrently) and Microbiology 503. 2 lectures; 2 laboratories; 4 credits.



**803. Microbial Cytology**

The fine structure of bacteria and related organisms. (Procaryotic Protists). Application of current techniques for the demonstration and isolation of external appendages, cell walls, cytoplasmic membrane, protoplasts, inclusions, and chromatin bodies. Prerequisite: Microbiology 701. 2 lectures; 2 laboratories; 4 credits.

**804. Microbial Genetics**

An introduction to genetic principles and methodology applicable to microorganisms; fine structure of genetic material, mutation, selection, adaptation, recombination, transformation, and transduction. Mr. Hickson. Prerequisite: permission of instructor. 2 lectures; 2 laboratories; 4 credits.

**897-898. Microbiology Seminar**

Reports and discussions on microbiological literature and recent developments in microbiology. Staff. Prerequisite: permission of instructor. 1 credit.

**899. Master's Thesis**

6-10 credits.

**999. Doctoral Research**

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**Music (63) (64)**

Chairman: *Keith Polk*

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PROFESSORS: Karl Bratton, Donald Steele

ASSOCIATE PROFESSORS: Alan Grishman, John Whitlock, John Wicks

ASSISTANT PROFESSORS: Mark DeVoto, Stanley Hettinger, Keith Polk, John Rogers, Howard Williams

VISITING ASSISTANT PROFESSOR: Mary Rasmussen

The Department of Music offers programs leading to the degrees of Master of Arts in Music and Master of Science in Music Education.

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**Master of Arts in Music**

Concentration in this degree is in the field of music history. Music theory is also emphasized, as are the disciplines of bibliography and research, analytical studies of music literature, and readings in source material. Performance study is encouraged. The following courses are required: Music 855, 856, 857, 858, 891, 893. The remainder of the courses may be drawn from the 700 series in Music or the 600, 700, and 800 series in other departments, with the permission of the adviser. Sufficient electives are required to total 30 credits. It is recommended that a student allow more than two semesters for completion of the program.

Admission to the program depends upon a Bachelor of Arts degree in Music or its equivalent from an accredited institution. Placement examinations in music theory, music history, and in piano are administered by the Department of Music. Students are encouraged to take these exams in the semester or summer preceding their entrance into the graduate program. Students not meeting standards in these phases of achievement will be required to make up their deficiencies. A reading test in German is also required.

### Master of Science in Music Education

Admission to this program depends upon an appropriate Bachelor's Degree in Music Education or its equivalent from an accredited college. A placement examination is administered by the Department of Music. Deficiencies must be made up.

The goal of this degree is to develop a broad knowledge at the graduate level in the fields of music education, performance, history, theory, and independent study. Each candidate will be required to complete one of the following: a professional paper; a field study in music education; a satisfactory recital appearance; a major composition, orchestration, or band arrangement; or the preparation and conducting of a major work in public performance for band, orchestra, or choir. The following courses must be taken: Music 855, 893, Music Education 796, 883 or 884. Also required are 6 credits in the Department of Education from courses such as the following: Education 820, 855, 858, 865, 883, 886, 892, and the 700 courses. Vocal or instrumental study at the 800 level is required to a minimum of 4 credits. A maximum of 9 credits is allowed if the graduate recital option is elected. Sufficient electives are required to total 30 credits.

### Music (63)

#### 701. Music of the Medieval Period

The nature of the beginnings of polyphony. The preeminent influence of the church in the thirteenth century and the rising secular movement in the fourteenth. Music as a dominant force in the political and social life of the Middle Ages. Mr. Polk. 4 credits.

#### 703. Music of the Renaissance

A study of the works of the composers of the fifteenth and sixteenth centuries from Dunstable to Palestrina. Mr. Polk, Mr. Wicks. 4 credits.

#### 705. Music of the Baroque

A study of the music of Europe from Derore to Handel. Particular attention is given to the profusion of styles and forms in the seventeenth century. Mr. Wicks. 4 credits.

#### 707. Music of the Classical Period

The growth of musical styles and forms from early classical, Baroque-influenced composers, through the high classicism of Haydn and Mozart, to the budding romanticism of the young Beethoven. The class will hear representative works in the areas of symphony, concerto, and opera. Mr. Grishman. 4 credits.

#### 709. Music of the Romantic Period

The symphonies, concerti, chamber music, and keyboard works of Beethoven, Berlioz, Schubert, Mendelssohn, Schumann, Brahms, Franck, Chopin, and Liszt. Romantic elements contained in the development of harmony orchestration, sonority, expressive content. The rise of the short piano piece, the German art song, the symphonic poem, nationalism in music. Mr. Steele. 4 credits.

#### 711. Music of the Twentieth Century

Music of the Twentieth Century, including its literature, its trends, and an analysis of techniques, styles, forms, and expression. Mr. DeVoto. 4 credits.

**721. The Life and Works of Beethoven**

The piano sonatas, the concerti, symphonies and string quartets. Lectures, analysis reports, required readings, and listening. Mr. Steele. 4 credits.

**731. The Lied**

Study of the history and literature of the German art-song, with special emphasis on the nineteenth and early twentieth centuries. Prerequisite: permission of the instructor. 4 credits.

**732. The Art Song**

This course will emphasize the non-German song of the late nineteenth and twentieth centuries. Prerequisite: permission of the instructor. 4 credits.

**733. Survey of Opera**

An investigation of representative masterpieces of this art form through listening, reading, and discussion. Mr. DeVoto. 4 credits.

**734. Survey of Oratorio**

This course attempts to place the oratorio in clear historical perspective in relation to other forms of church music to opera. Mr. Wicks. 4 credits.

**735, 736. Survey of Pianoforte Literature**

This history and development of keyboard literature from Bach to the present. A discussion and performance of the works of Bach, the sonatas and concertos of Haydn, Mozart, Beethoven, Schubert, the Romantic composers, and of contemporary writers. Mr. Steele. 4 credits.

**755, (755). Performance Studies in Medieval Music**

An investigation of music for vocal, vocal-instrumental and instrumental ensemble, circa 1100 to 1450, and its realization in performance, especially with regard to rhythm, *musica ficta*, notation, melodic ornamentation, improvised polyphony, and the clear projection of a polyphonic texture. Course work includes an evaluation of the writings of selected Medieval theorists and modern scholars; practical exercises in transcription; and performance on reconstructions of Medieval instruments, especially the organ, harp, psaltery, rebee, vielle, and recorder. Mr. Polk. 2 or 4 credits.

**756, (756). Performance Studies in Renaissance Music**

An approach to the problems of musical performance, circa 1450 to 1600, via the small vocal, vocal-instrumental and instrumental ensemble, with special reference to rhythm and tempo, *musica ficta*, text underlay, articulation, diminution, tablature notation, and effective distribution of voices and instruments. Course work includes a survey of performance manuals, iconographical sources, and current research; development of editing technique through the preparation of transcriptions; and an opportunity to perform on representative musical instruments of the period, notably the organ, harpsichord, lute, viols, recorders, cornetto, and trombones. Mr. Polk, Miss Rasmussen. 2 to 4 credits.

**757, (757). Performance Studies in Baroque Music**

A study of performance practices in solo keyboard works, sonatas *a 2* and *a 3* and solo cantatas, circa 1640 to 1750, concentrating on ornamentation, realization of figured basses, improvisation, articulation, rhythm, keyboard registration, and the influence of the construction of baroque musical instruments

(including the organ) on sonority and technique. Course work includes an examination of manuscripts (on microfilm), prints, treatises, and iconographical sources, and the editing and realization of selected works for recital performance. Miss Rasmussen, Mr. Wicks. 2 to 4 credits.

### **758. (758). Performance Studies in Classical Music**

An intensive examination of musical styles, circa 1760 to 1815, through the performance of keyboard music and instrumental chamber music, emphasizing the relationship between structure and interpretation, late eighteenth century conventions of ornamentation and articulation, a survey of tutors and relevant theoretical writings, and a critique of currently published editions and editing techniques. Mr. Grishman, Miss Rasmussen. 2 or 4 credits.

### **759. (759). Performance Studies in Nineteenth-Century Music**

The art of performing and coaching *Lieder*, piano music, and instrumental chamber music from Schubert through Debussy, with special consideration given to effective ensemble, traditions of interpretation, and the influence of structure on performance. Mr. Steele, Mr. Grishman. 2 to 4 credits.

### **760. (760). Performance Studies in Twentieth-Century Music**

Performance of representative twentieth century compositions for small instrumental or vocal-instrumental ensemble, with intensive work in structural analysis, rhythmic ensemble coordination, dynamic and articulation control, new instrumental techniques, notation, improvisation, and the interaction between jazz and European styles. Mr. Polk, Mr. Rogers, Mr. Verrette. 2 or 4 credits.

### **771, 772. Counterpoint**

First semester: sixteenth century polyphony based on the style of Palestrina. Second semester: free instrumental counterpoint based on the styles of Bach and Handel. Twentieth century counterpoint will be discussed in the closing classes of the course. Mr. Rogers. Prerequisite: Theory II or permission of instructor. 2 credits.

### **773. Canon and Fugue**

Free counterpoint in three and four parts, double counterpoint, the writing of simple two-part inventions, choral preludes, etc. The canonic and fugal studies will be based largely upon the works of Bach and will have as their objective the composition of a two-, three-, and four-voiced fugue. Mr. Williams. Prerequisite: Music 719-720 or permission of instructor. 2 credits.

### **775-776. Composition**

The various smaller harmonic forms, the variation, the rondo, and the sonata forms will serve as models for composition. Mr. Williams, Mr. DeVoto. Prerequisite: permission of instructor. 2 credits.

### **777-778. Advanced Composition**

This course will cover material ranging from strict composition in the "traditional forms" to free composition in "contemporary forms." Exactly what is to be stressed will depend on the makeup of the class. Work will be done on an individual and group basis. Mr. Williams, Mr. Rogers. 4 credits.

### **779. Orchestration**

Instruments and methods of combining them into coherent arrangements arriving at successful balances for the band and orchestral arranger. The character-

istics, range, and tone quality of the instruments are fully covered and transcriptions are made. Orchestral effects are studied. Chorestration is offered during the latter part of the second semester. The techniques of writing for solo voices, for mixed voices, men's and women's voices are taken up through the medium of arrangements and original work. Mr. DeVoto, Mr. Rogers. Prerequisite: permission of instructor. 4 credits.

**781. Form and Analysis**

A consideration of various formal and textural elements as concepts and within the context of musical examples. Thorough analysis of smaller and larger masterworks from the standpoint of harmony, counterpoint, structural line, and formal articulation. Mr. DeVoto. Prerequisite: permission of instructor. 4 credits.

**795. Special Studies in Music Literature**

Presuming a sound musical background, this course allows the student to investigate independently and in depth any of a vast range of subjects. Barring duplication of material, this course may be repeated for credit. Prerequisite: permission of the instructor. 4 credits.

**817, (817). Applied Music for Graduate Credit**

(1) Piano; (2) Organ; (3) Violin, Viola; (4) Violoncello; (5) Voice; (6) Woodwind; (7) Brass; (8) Percussion. Further development of technique, music interpretation, and repertory. Emphasis may also be directed toward the functional use of the instrument in the schoolroom. Prerequisite: must exhibit sufficient proficiency to warrant graduate study and permission of Department Chairman and the student's graduate supervisor. Audition required. A student may register for credit in the same courses in successive years with the approval of his major professor. Music staff. 1-2 credits.

**855. Introduction to Bibliography**

The student will become familiar with the reference materials of music, dictionaries, journals, and periodicals, and with major monographs and editions. Miss Rasmussen. 3 credits.

**856. Readings in Music History: Antiquity to 1600**

An opportunity to read and study in detail a restricted number of monographs and editions. Mr. Polk. 3 credits.

**857. Readings in Music History: 1600-1820**

An opportunity to read and study in detail a restricted number of monographs and editions. Mr. Wicks. 3 credits.

**858. Readings in Music History: 1820 to the Present**

An opportunity to read and study in detail a restricted number of monographs and editions. Mr. DeVoto. 3 credits.

**891, 892. Research Seminar**

Guidance in individual research projects. Permission of instructor. Variable credit.

**893. Theory Seminar**

Through reading, analysis, and composition, the student is acquainted with music theory from the Middle Ages to Monteverdi. Permission of instructor. Mr. Polk. 3 credits.

### 894. Theory Seminar

Theory and practice from the Baroque to contemporary music. Performance practice in the Baroque and later periods. Score analysis. Mr. Rogers. 3 credits.

## Music Education (64)

### 741-742. Techniques and Methods in Choral Music

A lecture-workshop course touching upon some of the problems and solutions in the organization and performance of high school and college glee clubs and community choirs. Emphasis is placed on techniques of choral conducting and rehearsal, repertory, and materials. Offered to Music Education students who wish to place a greater emphasis on a vocal option in the curriculum rather than instrumental. A student taking 751, 752 may substitute them for two of the instrumental techniques and methods courses. Mr. Bratton. 2 credits.

### 743. Materials and Methods in Piano Music

This course in the methodology and materials of beginning piano instruction is designed to give all potential piano teachers a coherent but flexible approach to the instruction of students of different ages and levels of talent. This course should also be available for the Music Education students who are not basically pianists but who are often called upon to give piano instruction. Mrs. Edwards. 2 credits.

### 745-746. Techniques and Methods in String Instruments

Class and individual instruction on stringed instruments, students are expected to practice four hours per week as a basic course requirement. A high level of instrumental proficiency results from intensive training on the violin, viola, cello, and double bass, enabling participants to perform in string ensembles. The course will explore classroom procedures, the establishment of string programs, and the evaluation of available methods materials. Mr. Grishman. 2 credits.

### 747-748. Techniques and Methods in Woodwind Instruments

Basic fundamentals of performance in woodwind instruments, techniques of class instruction, associated acoustical problems, and study of woodwind literature. Emphasis in the first semester will be on clarinet, flute, and saxophone. The double reed instruments will be emphasized in the second semester. Mr. Hettinger. 2 credits.

### 749-750. Techniques and Methods in Brass Instruments

A basic course in embouchure formation, tone, tonguing, fingering, flexibility, accuracy, and range development as applied to the trumpet or baritone horn, French horn, and trombone, in conjunction with a survey of the methods, studies, solos, and ensembles most likely to be useful with grade school, junior high school, and high school players of brass instruments. Qualified, advanced students may elect honors work in composition, arranging, and ensemble coaching. Miss Rasmussen. 2 credits.

### 751. Techniques and Methods in Percussion Instruments

The basic skills necessary for performance on snare drum, tympani, mallet instruments, and the other percussion instruments used in bands and orchestras. Materials and methods of instruction are included. Mr. Whitlock. 2 credits.

**785. Music for the Elementary Classroom Teacher**

For the non-music specialist interested in utilizing music as a means of enriching children's lives. The correlation and integration of music in the school curriculum and the basic skills and techniques necessary. Also open to music specialists and school administrators. Mr. Whitlock. 4 credits. (Summer Session course.)

**787. Problems in the Teaching of School Music**

Aims, scope, and organization of materials and activities in the elementary schools in keeping with modern trends in educational philosophy. The child voice, its care, and development. A demonstration of materials and methods for the various grades. Observations of elementary school music. Mr. Whitlock. Prerequisite: Education 658. 3 lectures; 1 laboratory; 2 credits.

**791. The Teaching of School Music**

The application of educational principles to the teaching and learning of music, and the organization of the music curriculum on the junior and senior high-school levels. The adolescent voice and the classification of voices; the selection of vocal and instrumental materials to fit the needs of the individual group, in order to ensure the maximum growth and musical development of the students; and the building of unified concert programs. Problems of administration and management, and the relationship of the teacher to school and community. Observation of music programs in secondary schools. Mr. Whitlock. Prerequisite: Education 658. 3 lectures; 1 laboratory; 4 credits.

**796. Organization and Administration of School Music Groups**

Problems of organizing and administering school orchestras, bands, glee clubs, choruses and small ensembles, such as objectives, motivation, schedule, discipline, equipment, programs, finances, rehearsal techniques, contests and festivals, materials, personnel selection, and grades. Mr. Whitlock. 3 credits.

**883. Instrumental Literature and Its Performance**

Exploration of representative solo and ensemble music for string, wind, and percussion instruments. Typical literature from each period of music is studied. As much as is possible, live performance is included, recordings used as required. Detailed attention given to interpretation. Project required. Mr. Grishmann, Mr. Hettinger. 3 credits.

**884. Choral Literature and Its Performance**

Analysis, discussion, and conducting of excerpts from choral masterpieces from all major periods and styles. Students will have opportunities to act as assistant conductors for some of the choral organizations on campus. Evaluation of current high school and college choral repertoires. Mr. Bratton. 3 credits.

## Physics (86)

Chairman: *Lyman Mower*

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PROFESSORS: Edward L. Chupp, Robert E. Houston Jr., John A. Lockwood, Robert H. Lambert, Lyman Mower, John E. Mulhern Jr., William R. Webber

ASSOCIATE PROFESSORS: David G. Clark, Richard L. Kaufmann, Robert E. Simpson

ASSISTANT PROFESSORS: Roger L. Arnoldy, L. Christian Balling, John F. Dawson, John Dowling Jr., Mark P. Klein, Harvey Shepard

GRADUATE ADVISER: John A. Lockwood

The Physics Department offers courses leading to three graduate degrees: Master of Science for Teachers, Master of Science, and Doctor of Philosophy. Graduate students entering in the Master of Science and Doctor of Philosophy programs are expected to demonstrate a proficiency in undergraduate work equivalent to that of the senior year in physics at the University of New Hampshire. To assist in starting a student's work at the proper level, a placement examination is required of all entering graduate students. This examination will be offered prior to the fall registration period.

### Master of Science for Teachers

The degree of Master of Science for Teachers is offered for candidates who satisfy the general admission requirements (see page 19) or who hold a secondary school teacher certification in physics or in general physical science. The course leading to this degree will normally be chosen so as to improve the candidate's ability to teach physics or general physical science at the secondary school level. These courses should total at least 30 semester hours and should be chosen in consultation with the graduate adviser in physics. Persons interested in this degree should confer with the Department Chairman or the graduate adviser.

### Master of Science Degree

For admission to graduate study in physics leading to a Master of Science Degree, the student should have completed 24 to 30 semester hours of undergraduate courses in physics. Suitable undergraduate preparation in mathematics is essential to graduate study in physics and should include differential equations, linear algebra, and advanced calculus. Candidates for admission are also required to take the Graduate Record Examination (both the aptitude test as well as the advanced test in physics). The results of this examination will be used in conjunction with transcripts to evaluate the applicant's undergraduate training. The courses required for a Master of Science degree include Physics 833, 839, 841, and 843. Candidates may select one of the following two options:

a) Complete 30 semester hours of courses chosen in consultation with the graduate adviser.

b) Complete 24 semester hours of courses chosen in consultation with the graduate adviser, complete a thesis representing the equivalent of 6 semester hours work, and pass an oral examination on the thesis.



## Doctor of Philosophy Degree

For admission to graduate study in physics leading to a Doctor of Philosophy degree, the student should satisfy the same general admission requirements as for a Master of Science Degree. In addition, he is expected to demonstrate an outstanding proficiency in undergraduate physics. Candidates for the degree must pass the placement examination with distinction within one year of enrollment. Admission to candidacy for the degree is based on demonstrated ability in formal course work, satisfaction of the language requirement, and passing a written and oral qualifying examination based on courses in the graduate physics curriculum. For students entering with a Master's degree, the qualifying examination must be taken within one year of enrollment; for students entering with a Bachelor's degree, the qualifying examination must be taken within two years of enrollment. Students are allowed two attempts to pass the qualifying examination. Finally, upon completion of a thesis, the doctoral candidates will take an oral examination based on his area of research.

The courses required for a Doctor of Philosophy degree consists of 831, 833, 839, 841-842, 843-844, and five courses selected as follows:

- a) Two courses from any *one* of the following areas:

Area 1 835-836 Statistical Physics  
 Area 2 861-862 Quantum Mechanics  
 Area 3 863-864 Nuclear Physics  
 Area 4 865-866 Solid State Physics  
 Area 5 850, 852 Plasma Physics

- b) Three additional courses chosen from the above list of areas.

The language requirement consists of demonstrating a reading ability in one of the following foreign languages: German, French, or Russian. This requirement may be satisfied by any one of the following methods:

- a) Satisfactory performance on the Educational Testing Service foreign language examination.

- b) Satisfactory performance on the reading examination administered by the department.

- c) *After* two attempts at either a) or b), the requirement may be satisfied only by the completion of a one-year course in the language.

## Chemical Physics Option

Doctor of Philosophy candidates in physics may elect to enter the Chemical Physics program, an interdisciplinary program offered jointly with the Department of Chemistry. In this option the doctoral student, with the advice of his guidance committee, elects courses in physics and chemistry (or, in some cases, mathematics), writes his dissertation on a research problem (experimental, theoretical, or both) appropriate to interdisciplinary treatment, and receives the doctorate in either physics or chemistry. In addition, each candidate must satisfy certain other requirements of the department in which the degree is granted. Ordinarily, students choosing the chemical physics option are expected to have undergraduate degrees in physics, chemistry, or mathematics and reasonably strong backgrounds in the other two disciplines.

### 607. Physical Optics

The electromagnetic theory of light, interference, diffraction, polarization, related phenomena, and non-linear optics. Prerequisite: Mathematics 527. 3 credits.

### 701. Introductory Quantum Mechanics

Quantum mechanics with application to atomic and molecular spectra. Prerequisite: Mathematics 635 passed or taken concurrently. 3 credits.

### 702. Atomic and Nuclear Physics

Natural radioactivity, nuclear reactions, nuclear scattering, models of the nucleus, high energy nuclear physics, cosmic rays. Prerequisite: Physics 701. 3 credits.

### 703-704. Electricity and Magnetism I and II

Foundation of electromagnetic theory, including electrostatics, dielectric theory, electromagnetism, magnetic properties of matter, alternating currents, Maxwell's field theory, and an introduction to electrodynamics. Prerequisite: Physics 507 and 508, or equivalent Mathematics 635 passed or taken concurrently. 3 credits.

### 831-832. Mathematical Physics

Differential equations of physics, complex variables, orthogonal functions, variational methods, matrices, vector, and tensor analysis. 3 credits.

### 833-834. Experimental Physics

Modern research techniques, including discussion and laboratory exercises in fundamental measurements in optics, electromagnetism, nuclear, atomic, and molecular phenomenon. 1-3 credits.

### 835. Statistical Physics I

A review of thermodynamics and kinetic theory, followed by an introduction to statistical thermodynamics. Prerequisite: Physics 831 or permission of instructor. 3 credits.

### 836. Statistical Physics II

Basic formulation and application of statistical mechanics to physical problems. (Offered on request.) Prerequisite: Physics 844. 3 credits.

### 837. Mathematical Physics

Formulation and solution of physical problems grouped according to their mathematical properties. (Offered on request.) Prerequisite: Physics 831-832. 3 credits.

### 839. Theoretical Mechanics

Newtonian, Lagrangian, and Hamiltonian formulation of the classical mechanics of particles and rigid bodies, with particular attention to those topics that serve as background for the study of modern physical theories. 3 credits.

### 841-842. Electromagnetic Theory

The formulation and detailed application of electromagnetic theory to physical problems. Prerequisite: permission of instructor. 3 credits.

### 843-844. Quantum Mechanics

Wave mechanical and Dirac formulations of non-relativistic quantum mechanics. Prerequisite: Physics 701, 839. 3 credits.

**850. Plasma Physics I (Hydromagnetic Phenomena)**

Steady state conditions, hydromagnetic waves, turbulence, shock waves, and individual particle motion will be discussed. 3 credits.

**852. Plasma Physics II**

A description of Plasma Physics from the Kinetic Theory point of view. (Offered on request.) Prerequisite: Physics 835. 3 credits.

**861-862. Advanced Quantum Mechanics**

Generalized formulation of quantum mechanics, formal scattering theory, and introduction to relativistic theory. Field theory, and related topics. Prerequisite: Physics 839 and 844. 3 credits. (Offered alternate years.)

**863-864. Nuclear Physics**

Formulation of theory underlying current experiments. Prerequisite: Physics 843. 3 credits. (Offered alternate years.)

**865-866. Solid State Physics**

Development of quantum mechanical theory of solids, transport phenomena, etc. Prerequisite: Physics 843 and 835. 3 credits. (Offered alternate years, not offered 1970-71.)

**887. Introduction to Space Science**

Detailed study of the earth and its physical environment, interplanetary medium, magnetosphere, the solar system, and beyond. Prerequisite: permission of instructor. 3 credits.

**889-890. Space Physics Seminar**

Lectures and discussions of current research in the physics of fields and particles in space. 1-3 credits.

**891, 892. Problems in Theoretical Physics**

May be taken more than once. (Offered on request.) 3 credits.

**893, 894. Problems in Experimental Physics**

May be taken more than once. (Offered on request.) 3 credits.

**895, 896. Special Topics**

Any special fields of study not covered by the above courses may be included. Choice of topic to be determined by class. May be taken more than once. 1-3 credits.

**897-898. Colloquium**

Required of all graduate students. Topics to be selected. No credit.

**899. Master's Thesis**

6 credits.

**999. Doctoral Research**

## Plant Science (32)

Chairman: *Lincoln C. Peirce*

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PROFESSORS: Gerald M. Dunn, C. A. Langer, Lincoln C. Peirce

ASSOCIATE PROFESSORS: Owen M. Rogers, Douglas G. Routley

ASSISTANT PROFESSORS: George O. Estes, J. Brent Loy, Otho S. Wells

The graduate research program in Plant Science is concerned with solving basic and applied problems associated with growth and response of crop plants to environment. Facilities include laboratories, field and greenhouse research areas, and plant growth chambers.

Program emphasis is directed toward breeding and genetics and toward crop physiology or biochemistry. Research and teaching in plant genetics, cytogenetics, and plant breeding is a major strength and is complemented by expanding University programs in statistics and genetics. (See description of Genetics Program.) Increased emphasis also is being given to research in plant physiology and plant biochemistry. In certain instances these research areas are integrated with the genetics projects to provide unique approaches toward solving fundamental problems.

It is recommended that all graduate students first complete work for the Master of Science degree. Candidates for this degree will be required to pass an oral examination and will be required to prepare a thesis. Candidates for the Doctor of Philosophy degree, in addition to the general requirements, must also demonstrate proficiency in a language approved by the major department. This requirement may be satisfied during graduate study or upon entering graduate school either by presenting 8 college semester credits with each course grade no less than B, or by passing a language examination approved by the Department. In general, German, French, Spanish, and Russian are considered acceptable for American students. Foreign students whose native language is not English will satisfy the language requirement by passing a qualifying English examination administered by the Department. A thesis on original research in the student's area of specialization is required for the doctoral degree.

### 706. Plant Physiology

Structure and properties of cells, tissues, and organs; absorption and movement of water; metabolism; growth and irritability. Botany and Plant Science staff. Prerequisite: Botany 411 or Botany 503 or Plant Science 421 and one year of chemistry. 2 lectures; 2 laboratories; 4 credits.

### 708. Plant Nutrition

Nutrient requirements of plants; ion uptake, translocation and accumulation mechanisms; role of elements in metabolic processes. Genetic and environmental factors governing nutrient absorption composition of plants. Mineral element and soil-plant relationships governing nutrient availability; growth, yield and crop quality as influenced by nutrient status; characteristics and formulation of commercial fertilizers. Laboratory emphasis on analytical procedures and instrumentation for soil and plant tissue analysis. Mr. Estes. Prerequisite: Plant Physiology, Organic Chemistry, Soils. 3 lectures; 1 laboratory; 4 credits.

**710-711. Advanced Topics in Plant Science**

A flexible course structure permitting independent study of group discussion of advanced technical or scientific topics. 2 or 4 credits. Students should consult with appropriate course coordinator before registering.

R-1 Physiology — Mr. Estes

R-5 Fruit Crops — Mr. Loy

R-2 Genetics — Mr. Dunn

R-6 Field Crops — Mr. Estes

R-3 Ornamentals — Mr. Rogers

R-7 Turfgrass — Mr. Dunn

R-4 Vegetable Crops — Mr. Peirce

**762. Plant Metabolism**

The function, occurrence, synthesis, and degradation of plant constituents. Emphasis is placed on respiration and photosynthesis and the metabolism of nitrogenous and aromatic compounds. Biochemical mechanisms such as those involved in seed dormancy, fruit ripening, and disease resistance are discussed in relation to their roles in plant survival. Prerequisite: General Biochemistry. 2 or 4 credits.

**769. Plant Growth Regulators**

Study of hormones and plant growth substances; relationships to differentiation and development of plant tissues. Mr. Routley. Prerequisite: Plant Physiology, Biochemistry. Laboratory optional. 2 or 4 credits. (Alternate years; offered fall 1971.)

**773. Methods and Theory of Plant Breeding**

Theory and use of plant breeding systems with emphasis on improving quantitative traits. Mr. Peirce. Prerequisite: Genetics, Statistics. 3 lectures; 1 laboratory; 4 credits. (Alternate years; offered fall 1970.)

**832. Development Genetics**

Relation of protein, RNA and DNA synthesis to development, chromosome differentiation, nuclear-cytoplasmic interactions, genic and non-genic control of sub-cellular organization, cellular continuity, cell associations, experimental embryology, hormones and post-embryonic development, and neoplastic growth. Mr. Loy. Prerequisite: permission of instructor. 3 credits. (Alternate years; offered spring 1971.)

**851. Plant Genetics**

Linkage, euploidy, aneuploidy, cytoplasmic inheritance, mutation, and genetics of disease resistance. Mr. Dunn. Prerequisite: Genetics. 3 credits. (Alternate years; offered fall 1971.)

**853. Cytogenetics**

Chromosome aberrations and their behavior. Effect of radiation on chromosomes. Mapping and laboratory techniques in cytogenetic analysis. Mr. Rogers. Prerequisite: Genetics, Cytology. 2 lectures; 1 laboratory; 3 credits. (Alternate years; offered fall 1970.)

**895-896. Research in Plant Science**

Advanced investigations in a research subject, exclusive of thesis. Staff. 1-4 credits.

**897-898. Graduate Seminar**

Library research and discussion of current topics of Plant Science. Required of all graduate students majoring in Plant Science. Staff. 1 credit.

### 899. M. S. Thesis

A thesis requiring study in depth of a phase of Plant Science. Required of all M.S. candidates in Plant Science. 6-10 credits.

### 999. Doctor of Philosophy Thesis

Dissertation reflecting independent research in a phase of Plant Science is required. Credit received upon completion.

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## Political Science (52)

Chairman: *George K. Romoser*

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PROFESSORS: Robert B. Dishman, John T. Holden, George K. Romoser

ASSOCIATE PROFESSORS: Erwin A. Jaffe, David L. Larson, Peter Savage, John Woodruff, Frederic Wurzburg

ASSISTANT PROFESSORS: John R. Kayser, Lawrence W. O'Connell, Ann T. Schulz

A candidate for admission to graduate study in the Department of Political Science is normally expected to have majored in Political Science or a closely related field as an undergraduate, and to have achieved an academic record of some distinction. In exceptional cases, however, the Department will waive this requirement, provided the candidate will follow without credit a program of study agreed upon by the student and the departmental adviser and Chairman. This waiver is usually reserved for the unusual student.

The Department offers the Master of Arts in Political Science and the Master of Public Administration. The candidate in each of these programs is expected to complete eight full courses of four credits each, for a total of thirty-two credits. Of these eight courses, it is recommended that two courses be taken in a related discipline, and more may be taken outside the Department with the approval of the adviser and the Chairman. It is also expected that the candidate will develop an area of concentration among the fields offered by the Department: American Politics, Comparative Politics, International Relations, Political Thought, and Public Administration. The student is required to take Political Science 899, Directed Research and Study, in which he will write a research paper in his major field of interest. Where it is necessary to his program of study and research, the student must demonstrate capability in the relevant foreign language, or capacity in the tools of quantitative analysis.

To receive a master of Public Administration degree a candidate must complete eight full courses of four credits each, for a total of thirty-two credits. Of these eight courses, four will deal with the administrative process, two will be in statistics and research in government problems, and the remainder will be selected to suit the particular interests of the candidate. The degree is designed for individuals intending to pursue an administrative career. Candidates are expected to serve an internship for which they receive academic credit.

Candidates for advanced degrees are expected to take courses at 700-800 levels in Political Science and related disciplines, and to maintain a passing grade (P) in all courses.

Consult the Department for schedule of courses offered in a particular semester.

## American Politics

### 715, 815. Urban and Metropolitan Politics

Planning, management, and problems of the urban community. Mr. O'Connell. 4 credits.

### 716, 816. Political Parties and Voting Behavior

Functions, organization, operation, and bases of electoral support of American political parties. 4 credits.

### 717, 817. Pressure Groups and Public Policy

Functions, organization, operation, and bases of support of American pressure groups. 4 credits.

### 718, 818. Psychology of Political Behavior

Cultural, social, economic, and emotional forces molding the citizen's political activity. 4 credits.

### 719, 819. Legislative Behavior

Role, organization, operation, and conduct of American legislatures. Mr. Dishman. 4 credits.

### 720, 820. The President as Political Executive

The American president's ways and means of pursuing political objectives. Mr. Dishman. 4 credits.

### 721, 821. Administrative Process

The administrative and bureaucratic process in public life. Mr. O'Connell, Mr. Savage. 4 credits.

### 722, 822. Administration of Justice

Criminal and civil justice under various legal institutions; contemporary role of police, prosecutors, judges, juries, counsel, and interest groups in the legal process. 4 credits.

### 723, 823. Supreme Court and the Judicial Process

The Supreme Court as interpreter of law and arbiter among forces in American politics. Mr. Dishman. 4 credits.

### 724, 824. Political Socialization

Pressures integrating the individual into the context of American political life. 4 credits.

### 725, 825. United States Foreign Policy

The formulation and execution of American foreign policy. Mr. Larson. 4 credits.

### 727, 827. Selected Topics in American Politics

Courses in American politics of a special nature not regularly offered. Staff. 4 credits.

## Comparative Politics

### 736, 836. Communist Systems

A comparative study of communist politics. 4 credits.

### **737, 837. 738, 838. Comparative and International Area Studies**

The politics of individual nations, groups of nations, or regions. The following listing of individual courses may be expanded or contracted from time to time, and courses will be offered as staff is available and student needs dictate: 1) Government and Politics of the U.S.S.R.; 2) Soviet Foreign Policy; 3) Government and Politics of China, Mr. Woodruff; 4) Government and Politics of Japan, Mr. Woodruff; 5) Contemporary South Asia, Mr. Holden; 6) Contemporary Southeast Asia, Mr. Holden; 7) Governments of Latin America, Mr. Larson; 8) Contemporary Politics in Europe, Mr. Romoser, Mr. Wurzburg; 9) Government and Politics of France, Mr. Wurzburg; 10) Government and Politics of Germany, Mr. Romoser; 11) Government and Politics of Canada, Mr. Woodruff; and 12) Government and Politics in the Middle East, Mrs. Schulz. 4 credits.

### **745, 845. Politics of Development**

Concepts of political change viewed in relation to existing political situations. Mr. Savage. 4 credits.

### **746, 846. Comparative Administration**

The history, organization, and potential of public bureaucracies as a political instrument. Mr. Savage. 4 credits.

### **747, 847. Selected Topics in Comparative Politics**

Courses in comparative politics of a special nature not regularly offered. Staff. 4 credits.

## **International Relations**

### **737, 837. 738, 838. Comparative and International Area Studies**

See listing under Comparative Politics. 4 credits.

### **755, 855. International Politics**

Problems and choices confronting nation-states in dealing with conflict of regional and international scope. Mr. Holden. 4 credits.

### **756, 856. Foreign Policies of the Great Powers**

Application of foreign policies in the international political process. Mr. Holden. 4 credits.

### **758, 858. International Law**

Theory, practice, and function of law in international disputes as analyzed from decisions of national and international tribunals. 4 credits.

### **759, 859. International Organization**

Collective security and cooperation through international organizations such as the League, United Nations, and regional bodies. Mr. Romoser, Mr. Larson. 4 credits.

### **767, 867. Selected Topics in International Relations**

Courses in international relations of a special nature not regularly offered. Staff. 4 credits.



## Political Thought

### 775, 875. Classical and Medieval Political Thought

Origins of political philosophy in the West, and political thinkers from the Greeks to Machiavelli. Mr. Kayser. 4 credits.

### 776, 876. Modern Political Thought

Modern political theorists from Hobbes to Marx. Mr. Jaffe. 4 credits.

### 777, 877. Contemporary Ideologies and Political Thought

Liberalism, conservatism, and radicalism; contemporary ideologies of commitment and scientism and their implications. Mr. Romoser. 4 credits.

### 787, 887. Selected Topics in Political Thought

Courses in political thought of a special nature not regularly offered. Mr. Romoser, Mr. Jaffe, Mr. Kayser. 4 credits.

## Scope and Methods

### 793, 893. Political Sociology

The social bases of political activity. 4 credits.

### 794, 894. Methods of Research in Political Behavior

Methodology and techniques in evaluating political behavior, surveys, experimental designs, and basic data processing. Aspects of computer technology and political research. 4 credits.

## Independent Study and Seminars

### 795, 796, 895, 896. Independent Study

Research in various fields on subjects of special interest to the student, carried out under the instructor's supervision. Staff. 4 credits.

- (1) American Politics.
- (2) Comparative Politics.
- (3) International Relations.
- (4) Political Thought.
- (5) Scope and Methods.

### 797, 798; 897, 898. Seminars

Small group discussion and examination of themes chosen by the instructor.

897 and 898 are offered independently from time to time as seminars limited to graduate-student enrollment.

- (1) American Politics
- (2) Comparative Politics
- (3) International Relations
- (4) Political Thought
- (5) Scope and Methods

Staff. 4 credits.

### 899. Directed Research and Study

4 credits.

## Psychology

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### Psychology (67)

Chairman: *Raymond L. Erickson*

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PROFESSORS: Raymond L. Erickson, George M. Haslerud, Frederick M. Jervis, Robert I. Watson

ASSOCIATE PROFESSORS: Peter S. Fernald, Gordon A. Haaland, Earl C. Hagstrom, Ronald E. Shor

ASSISTANT PROFESSORS: Robert G. Congdon, Kirk E. Farnsworth, G. Alfred Forsyth, John R. Forward, Leslie A. Fox, Burton I. Klinger, Edward F. Rutledge

### Doctor of Philosophy

The Department of Psychology offers a four-year program of study leading to the Doctor of Philosophy degree. The basic goal of the program is the development of behavioral scientists who can carry out sound research in an area of specialization and make meaningful contributions to the field of psychology. The rationale of the program requires that the development of specialized research competence take place within a larger context provided by theoretical and systematic psychology. In addition, a concern with other specific needs of the research psychologist who intends to become a college or university teacher is woven into the program. In his third year, the student has the opportunity to teach a small section of introductory psychology under close staff supervision while concurrently enrolled in a teaching seminar that has among its goals a deepening of the student's appreciation of the objectives and problems of teaching in the liberal arts.

The student may specialize in one of the three main areas: Experimental, social, or history and theory. Within experimental, substantive areas include perception, cognition, learning, and physiological psychology. The student's guidance committee will counsel with him to help plan an effective graduate program, which will typically require four years. Core courses taken by all students include methodology and statistics, history, theory, and systems in psychology, and the seminar and practicum in the teaching of psychology. Work outside the department also is included in each student's program. Depth in a particular area is obtained through participation in the graduate offerings listed in Group II below, and by independent study and research conducted under the supervision of a staff member. Psychology 895, 896, Reading and Research in Psychology, is specifically designed to serve this purpose.

Prior to his doctoral dissertation, the student will carry out original research that culminates either in a master's thesis or a paper of publishable quality. A Master's degree may be awarded as part of the student's program. Detailed information concerning language requirements and the qualifying examination for advancement to candidacy for the Ph.D. degree can be obtained from the department.

A student admitted to graduate study must meet the requirements for admission to the Graduate School. In applying for admission to the department's program, he must submit Graduate Record Examination scores on the verbal and quantitative sections of the aptitude test and his score on the advanced test in psychology.

To be accepted into the program, the applicant must desire to pursue the doctoral degree and be deemed qualified to do so on the basis of initial selection procedures. He need not necessarily have been an undergraduate major in psychology. However, before beginning his graduate career proper, he must have completed a minimum of 15 undergraduate credits in psychology, including courses in

elementary statistics, experimental psychology, learning theory, and systematic psychology.

Preference in admission will be given to those who have recently received their Bachelor's degree. Only under unusual circumstances will admission be granted to applicants who already hold a Master's degree.

## **Graduate Curriculum in Psychology**

The courses and seminars listed below provide the general framework within which the student will develop, with the counsel of his guidance committee, his program of research and study leading to the doctoral degree. The range and sequence of seminars will vary to some extent with each student, though there will be common features to all programs.

The 700 series courses are not normally taken for graduate credit, though a student may be advised to enroll in one of these courses as a way of improving his background in the field. Graduate credit for a 700 series course is permitted only with the previous approval of the student's adviser.

### **701, (701). Contemporary Topics in Psychology**

A non-credit seminar focusing on topics of particular interest to students in psychology. Jointly organized by students and faculty to respond to requests of students. No credit.

### **751, 752. The Development and Behavior of Man in the Social System**

A systematic examination of normal and abnormal behavior in the context of the social system. Problems of development, personality, and abnormal behavior are considered in the context of social psychological variables. Significant topics are socialization, personality theory, normal and abnormal behavior patterns, and social-influence processes. Prerequisite: Statistics. (Psychology 751 is prerequisite to 752.) 3 credits.

### **758. Psychology of Learning and Motivation**

The roles of learning and motivation are studied in relation to contemporary theories of behavior and integrated with other areas of psychology. Emphases are on theory, research methods, and applications. The major concepts and most recent research findings in the areas of learning and motivation are discussed. Prerequisite: Statistics. 3 credits.

### **778. Brain and Behavior**

The study of relationships between the nervous system and behavior. The course examines the physiological, neural, and biochemical mechanisms underlying instinct, memory, learning, emotion, and consciousness in man, as well as the evolution of these functions in lower animals. Prerequisite: Statistics. 3 credits.

### **789, (789). Special Topics**

Taught by a different staff member each year. The instructor presents advanced material in an area in which he has developed specialized knowledge through research and study. Students may repeat the course, but may not duplicate areas of specialization. Prerequisite: 16 major credits in Psychology or permission of instructor. 3 credits.

## **794. The History of Psychology: An Integration**

This course provides an opportunity for the major to reassess, extend, and integrate his knowledge of psychology within a historical perspective. Attention is given to antecedents in philosophy and the physical sciences and their relationship to the subsequent development of schools and systems of psychology. In addition, the course examines contemporary thought and research in the field. Normally taken during the senior year. Prerequisite: 20 major credits in Psychology or permission of the instructor. 3 credits.

## **795. (795). Independent Study**

This course provides the opportunity for a psychology major to pursue independent study with a member of the faculty. Arrangements are to be made with a specific faculty member, and enrollment is by permission only. 1-4 credits.

## **Graduate Seminars in Psychology**

### **Group 1 (To be taken by all first-year students)**

#### **801-802. Graduate Proseminar**

Students and graduate faculty in psychology meet every two weeks for a mutual exchange on current issues in psychology. No credit.

#### **803-804. History, Theory, and Systems in Psychology**

The nature of the science; directed toward increasing the student's awareness of both the strengths and limitations of the approach that characterizes psychology as a behavioral science. Attention is given to the philosophical bases upon which psychological research rests, the nature of psychological inquiry, the history of the study of behavior, and the evolution of theory-building in psychology. Mr. Watson. 3 credits.

#### **809-810. Research Methodology and Statistics I, II**

A consideration of research techniques and problems of methodology in psychology. The first semester stresses the principles of statistical inference, correlational approaches, and their interrelatedness in design. Topics considered include probability theory, linear regression, function-free prediction, the theory underlying statistical inference, parametric and non-parametric tests of significance, and principles of analysis of variance. The second semester extends the correlational approach to the techniques and methodology of multiple regression and considers the appropriate use and theoretical bases of complex designs. Mr. Forsyth. Prerequisite: undergraduate Statistics and Experimental Psychology. 3 credits.

#### **811. Research Methodology and Statistics III**

A continuation of Psychology 809-810 covering computer techniques in statistical analysis, factor analysis, and other commonly used multivariate analytical techniques. Mr. Fox. 3 credits.

### **Group II**

#### **820. Measurement and Assessment**

A seminar devoted to the nature of measurement in psychology. Emphasis is given both to the techniques for evaluating various assessment procedures and to the theory of data. Current issues in the problems of measurement will be

discussed and the course will culminate in a project relating the area of measurement to specific content areas of interest to the student. Mr. Fox. Prerequisite: Psychology 811. 3 credits.

**835. Advanced Psychopathology**

The current literature is utilized to gain perspective on the etiology and dynamics of the major forms of pathological behavior. Various theoretical orientations are examined with regard to their implications for the psychotherapeutic process. Mr. Klinger. Prerequisite: Psychology 752 or its equivalent. 3 credits.

**836. Cognitive Processes**

The more complex processes that characterize man. Concept formation, problem solving, creative thinking, and the relationship between cognition and effective behavior are among the topics examined in depth. Mr. Shor. 3 credits.

**838. Theories of Behavioral Change**

An examination of man's behavior in the process of problem-defining and problem-solving. Recognizing that solutions to problems are based on the definitions of problems, the course examines the process by which problems are defined. The essential nature of functional fixedness or set in problem-solving is examined in relation to insight and creativity. The defining and solving of problems is related to changes in the individual, the organization, and the nation. The course recognizes that man's experiences and his actions are the result of how he defines and attempts to solve problems. Mr. Jervis. 3 credits.

**841. Personality Theory**

The evolutionary development of the major personality theories, with particular reference to the theoretical, clinical, and experimental contributions to current theories. Mr. Fernald. 3 credits.

**843. Psycholinguistics**

Issues relevant to the development, structure, and functions of language. Topics include the problem of meaning, acquisition of grammar by the child, personality and voice, and the interrelationship of language and culture. 3 credits.

**851. Advanced Social Psychology**

A seminar devoted to theoretical and experimental support for major topics of current concern. These may include attitude change, power, interpersonal perception and attraction, roles, interaction, and analysis of structure and function in complex social systems. Mr. Haaland. Prerequisite: Psychology 752 or its equivalent. 3 credits.

**862. Psychology of Perception**

Experiments and theory concerning the organism's discrimination and interpretation of its apparent environment. An examination is made of perceptual models in learning and other areas of psychology. The course culminates in independent perceptual experiments carried out individually by each student. Mr. Haslerud. 3 credits.

**865. Advanced Physiological Psychology**

A seminar devoted to an intensive examination of specific topics relating behavior to its physiological correlates. Among the topics considered are receptor

functions, cortical mechanisms, memory, neural correlates of drive states, emotional behavior, and intracranial stimulation. Mr. Hagstrom. Prerequisite: Psychology 778 or its equivalent. 3 credits.

### **368. Evaluation of the Therapeutic Process**

The process of psychotherapy is examined in relation to relevant research findings. The role of the psychotherapist's working-theory is made explicit by showing its effect upon inferences made, goals set, and methods employed in changing the client. The student learns methods of evaluating various theoretical positions, including the identification of basic assumptions that underlie them. He is encouraged to identify the basic assumptions upon which he bases his own theoretical position. Mr. Jervis. 3 credits.

### **370. Advanced Psychology of Learning**

Problems in conditioning and other forms of learning. Emphasis is given to the evaluation of current experimental and theoretical literature. Mr. Rutledge. Prerequisite: Psychology 758 or its equivalent. 3 credits.

## **Group III**

### **891-892. Seminar and Practicum in the Teaching of Psychology**

Typical problems encountered in teaching psychology on the college level, including an examination of the implications of the liberal arts philosophy for teaching. Under close supervision of the staff, the student will be given an opportunity to teach an undergraduate section of introductory psychology. The seminar and practicum operate in close coordination throughout the year. Required of all doctoral students, typically during the third year. Mr. Erickson. 5 credits.

### **895, 896. Reading and Research in Psychology**

As part of his development as an independent scholar, the student is encouraged to plan: (1) broad reading in an area, (2) intensive investigation of a special problem, or (3) experimental testing of a particular question. The project may involve library research, empirical research, or both. Registration must be acceptable to the student's guidance committee and to the staff member who has agreed to serve as his adviser on the project. May be repeated. (1) Physiological, (2) Perception, (3) History and theory, (4) Learning, (5) Social, (6) Cognition, (7) Statistics and Methodology. Staff. 3-6 credits per semester.

### **897, 898. Problems and Issues in Psychology**

A seminar to be offered by one or more members of the staff concerning problems and issues of special importance in the current development of the field. On occasion the seminar will feature a problem which has been the subject of specialized research and study by a member of the staff. The personnel and topical focus will vary from year to year, and the course may be repeated by the student. Staff. 3 credits.

### **899. Master's Thesis**

Each student will carry out original research that culminates either in a master's thesis or a paper of publishable quality. 6 credits.

### **999. Doctoral Research**

**Group IV** (Graduate courses offered primarily for students enrolled in other graduate programs)

**822. Case Studies in Counseling**

Case studies are used to illuminate the differences among a variety of personality theories and counseling techniques. The seminar is designed to help develop an appreciation of the complexities of human behavior, to gain increased respect for the integrity of individuals and their difficulties in revealing themselves to a counselor, and to understand better the difficulties encountered in applying theoretical knowledge to the counseling situation. Mr. Farnsworth. 3 credits. (Offered only in the summer.)

**823. Individual Testing**

Training in the administration, scoring, and interpretation of individual tests of intelligence. Such instruments as the Wechsler Adult Intelligence Scale, the Stanford-Binet, and the Wechsler Intelligence Scale for Children will be critically analyzed. Each student will be required to purchase one set of tests materials. Miss Riggs. Prerequisite: permission of instructor. (Adequacy of the student's background in statistics, measurement, and personality theory will be evaluated by the instructor.) 1 lecture; 1 laboratory; 4 credits.

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## Resource Economics (21)

Chairman: *James R. Bowring*

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PROFESSORS: James R. Bowring, William H. Drew, William F. Henry

ADJUNCT PROFESSORS: George E. Frick, Nelson L. Le Ray

ASSOCIATE PROFESSORS: Richard A. Andrews, Owen B. Durgin, Edmund F. Jansen Jr.

ASSISTANT PROFESSORS: Chauncey T. K. Ching, Sherrill B. Nott

Admission to graduate study in Resource Economics may be granted those who have satisfied the requirements for admission to the Graduate School at the University of New Hampshire and present evidence of satisfactory undergraduate training. Normally, this will include two or more courses in Economics or Resource Economics for a total of four or more courses in Social Sciences, as evidence of preparation for advanced training in the field.

The Graduate Record Examination scores on the verbal and quantitative sections of the aptitude test must be presented. Foreign applicants, whose native language is not English and who have not received their secondary school or university education in the English language, must take the "Test of English as a Foreign Language." The test is diagnostic. Admission to those applicants whose scores indicate unsatisfactory command of English may be denied or may be made contingent upon evidence of improved command of English. If English has been the medium of instruction in the secondary school or university, a statement to this effect signed by an officer of a U. S. Embassy or Consulate or by an appropriate official of the educational institution involved should be sent to the Graduate School.

Candidates for the Master of Science degree will be required to pass a final examination. A thesis is normally a requirement for the degree. Approved course work may be substituted for the thesis.

### **701. Applied Statistics I**

Use of elementary statistical techniques in analysis of prepared data. Topics surveyed include elementary probability, discrete and continuous probability distributions, distributions of sample statistics, small sample theory, elementary analysis of variance, regression, correlation, chi square and non parametric analogues of regression and analysis of variance. Attention will be paid to the use of available computer programs to the solution of statistical problems. Mr. Durgin. 4 credits.

### **705. Structure, Economic Problems, and Planning of Communities in the Non-Urban Environment**

The community is taken as an economic unit and analyzed using appropriate methodologies with emphasis on economic growth. Economic forces, as they relate to employment, income, transportation, housing, etc., are analyzed. Community income, expenditures and public services are taken in the context of growth and planning. Mr. LeRay. Prerequisite: 1 course in Social Science. 4 credits.

### **706. Economics of Resource Development**

The classical and modern theories of economic development. Economic problems of land and resources in relation to market location, urban-rural conflicting demands, and conservation and water supply. Population mobility, capital needs, and the roles of public and private leadership will complete the framework for discussion of the major resource development problems of New England. Mr. Bowring. Prerequisite: Principles of Economics or equivalent. 4 credits.

### **707. Research Methods in Social Science**

The scientific method of research. Analysis of research problems in social sciences. The design of research and the application of research techniques to identifying and solving problems. May be used in place of Sociology 702. Mr. Drew. Prerequisite. 3 hours of statistics. 4 credits.

### **715. Linear Programming Methods**

Setting up and solving problems by the simplex and distribution methods; variation in linear programming methods with applications, non-linear programming, discrete programming, and solving input-output and game theory problems. Applications to firm and aggregate economic analysis. Mr. Andrews. Prerequisite: Mathematics of Business and Economics or Fundamental Mathematics or permission of instructor. 4 credits.

### **756. Regional Economic Analysis**

Concepts and methods of delimiting regional economies, theories of regional growth, methods of measuring regional economic activity, empirical approaches to regional economic planning and development, and public policies for regional economies. Although theoretical aspects of regional economics will be considered, primarily emphasis will be placed on empirical research studies and their policy implications for regional economic performance. Mr. Ching. Prerequisite: Intermediate Economic Theory, Elementary Statistics, Elementary Calculus, Elementary Linear Programming, or permission of the instructor. (Alternate years; offered in 1969-70.) 4 credits.



**758. Introduction to the Location of Economic Activity**

Economic theories explaining the behavior of individual firms and consumers in selecting sites for carrying on economic activities. The relationship of these theories to patterns of industrial location, systems of cities, and land-use competition in general. Problems of locational change and adjustment and the effects of public policy on spatial economic activities. Mr. Ching. Prerequisite: Resource Economics 715 or its equivalent, Mathematics 415 or its equivalent, or permission of the instructor. 4 credits.

**804. Economics of Production and Resource Use**

Principles of choice, resource use, and production under perfect and imperfect knowledge. The economic theory of resource allocation and the use of this theory in problem solving. Resource-product relationships, nature of cost, returns to scale, factor valuation and pricing, uncertainty, and interfirm relations. Mr. Andrews. 2 credits.

**807. Statistical Analysis**

Statistical measurement and research tools for use in the physical and social sciences. Regression, analysis of variance, factorial analysis, covariance, time series, sampling, and experimental design. Mr. Ching. 4 credits.

**809. Agricultural Economics**

Analysis of supply, demand, and price relationships. Appraisal of the economic theory relevant to decision-making in food production, marketing, and consumption, and on the competitive structure of the food industry. Mr. Henry. 3 credits.

**895-896. Investigations in Resource Economics**

Human-resource development, legal problems in resource development, economics of outdoor recreation, community development. Staff. 4 credits.

**899. Thesis**

To be arranged. 6-10 credits.

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## Sociology (68)

Chairman: *Arnold S. Linsky*

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PROFESSORS: Richard S. Dewey, Stuart Palmer, Solomon Poll, Murray A. Straus

ASSOCIATE PROFESSORS: Melvin T. Bobick, Peter Dodge, Richard E. Downs, Bud B. Khleif

ASSISTANT PROFESSORS: Thomas R. Burns, Richard L. Ingersoll, Arnold S. Linsky, Amnon Orent, Fred Samuels, Howard M. Shapiro

The Department of Sociology offers a program of graduate study leading to the degrees of Master of Arts and Doctor of Philosophy. The Master of Arts curriculum is largely designed to give the student the opportunity to acquire professional competence in the core areas of theory and methodology; the Doctor of Philosophy program presents the candidate with three substantive areas for possible specialization: social disorganization, social psychology, and comparative institutional analysis.

The student's proficiency in theory, statistics, and methods, and in the major and minor areas of study is determined by examination. No specific courses are required of all students. Within the context of a curriculum principally organized in the form of seminars and research under the supervision of assigned faculty members, the student is expected to select from the departmental specializations one major and one minor area for intensive study, which may in specified cases extend to work in contiguous disciplines. In designing the program most appropriate to the individual, his advisers will take into consideration both his past experience and his intellectual goals, and, given the guidelines sketched above, flexibility will be emphasized. The selection of dissertation topic is thus limited only by the areas of expertise available among departmental faculty members.

Upon establishing residence the student shall inform himself as to any modifications in the requirements of the degree program in which he is enrolled.

To be awarded the Master of Arts degree the candidate must fulfill the following requirements: 1) Complete satisfactorily at least one full year (24 hours) of graduate level course work. 2) Pass a two-hour examination in theory and methodology, *or* complete satisfactorily Sociological Methods I and II (801 and 802) and Sociological Theory I and II (811 and 812), in two of which he must achieve a grade of High Pass or better. 3) Write an acceptable Master's thesis.

To be awarded the Doctor of Philosophy degree the candidate must fulfill the following additional requirements: 1) Complete satisfactorily at least one full year (24 hours) of course work after the Master of Arts degree as well as the residence requirements of three years' work after the Bachelor of Arts degree. 2) Pass an oral and written examination in his major and minor areas of specialization and in advanced theory and methodology. 3) Demonstrate advanced reading knowledge of a foreign language. With the permission of his adviser and the Graduate Committee, a student may substitute for proficiency in a single language either: a) intermediate reading knowledge of two languages, or b) intermediate reading knowledge of one language and knowledge of a research tool not normally required of graduate students in sociology, such as symbolic logic, historiography, computer programming, econometric techniques, or mathematical statistics. 4) Write and defend an acceptable doctoral dissertation.

In planning his program of study the student will be advised at first by an assigned faculty member and subsequently, in the case of doctoral students, by a guidance committee. Specially appointed committees will be organized for the direction and assessment of the thesis and dissertation. Under such supervision the student is expected to go considerably beyond the minimal common requirements of the graduate program to establish a knowledgeability and competency peculiarly his own, but he will be permitted to take courses outside the Department or below the 700 level within the Department only with the express permission of his adviser.

To be accepted as a graduate student in sociology, the applicant must present, in addition to meeting the general Graduate School requirements, Graduate Record Examination scores on the verbal and quantitative sections of the aptitude test and his score on the advanced test in sociology. Undergraduate majors in the other social sciences, and others who have had a minimum of 18 credits in sociology, are regarded as suitable candidates for admission; but in some cases a comprehensive examination may also be required for admission. Ordinarily students will be admitted in the expectation of their completing the entire graduate program. Well qualified applications for a terminal Master of Arts degree, and applicants who have

initiated their graduate work in sociology at another institution, will, however, be given full consideration.

**701. Methods of Social Research**

Analysis of research problems; designing field studies and experiments; investigation of selected research procedures and techniques, e.g., sampling techniques, schedule construction, and interviewing techniques. Prerequisite: major in sociology or social service, or permission of instructor. 4 credits.

**702. Statistics**

Use of elementary statistical techniques in analyses of sociological data. Selected statistical techniques will be examined, e.g., probability, discrete and continuous probability distribution, distribution of sample statistics, nonparametrics, correlation and tests of significance. Prerequisite: Sociology 701 or permission of instructor. 4 credits.

**703. Criminology**

The scientific study and control of crime. The following are considered: indexes, rates and theories of crime and delinquency, police, courts, probation, prison, and parole. 4 credits.

**711. History of Social Theory**

An examination of the background and early formulation of sociological theory. Consideration will be given to the writings of classical social thinkers—Descartes, Comte, and Max Weber, among others. 4 credits.

**712. Contemporary Sociological Theory**

An exposition of the major schools of contemporary sociological theory; functionalism, "verstehen" sociology, symbolic interactionism, reform sociology, neopositivism, and formal theory construction. 4 credits.

**720. Current Developments in Family Sociology**

Study of the theoretical and empirical research on specific aspects of the family. A different topic will be selected each semester to reflect issues of current importance, for example: stratification and the family, intra-family communication, power structure of the family, kinship in modern societies. In addition to critical review of the literature, a class or individual research project will usually be carried out. Prerequisite: 8 credits of sociology; Sociology 520, The Family, recommended. 4 credits.

**727. Public Policy in Social and Labor Legislation**

American social and labor legislation of the recent decades. An opportunity is provided to study the way in which American economic and human values have been implemented and modified by law. Attention will be given to legislation and private industry programs in social security, reemployment, unemployment insurance, health services, training and retraining, and fair employment practice. Lectures, discussion, assigned reading, and individual student projects. Prerequisite: one year's work in economics or sociology. 4 credits. (Also offered as Economics 727.)

**735. Complex Organizations**

Analysis of the structure and dynamics of complex, formal organizations (business, military, political and governmental, and educational). Emphasis on the

construction of theory to account for the findings of empirical studies, both historical and comparative. Special problems treated in the course: power and social control in formal systems; organizational processes, performances, and effectiveness; impact of complex, formal organizations on persons and societies. Prerequisite: permission of instructor. 4 credits.

### **740. Culture Change**

Various types of society are studied leading to the development of a theory of culture change. Descriptive studies of institutional as well as theoretical materials, selected from the writings of Comte, Marx, Spencer, Durkheim, Spengler, Sorokin, Redfield, and others. Prerequisite: Sociology 400, Introductory Sociology, or permission of instructor. 4 credits.

### **741. Social Change and Societal Development**

Comparative, interdisciplinary approach to the study of social change. The course focuses on the interrelationships among economic, political, and social factors in determining the structure, dynamics, character, and level of development of societies. Prerequisite: permission of instructor. 4 credits.

### **745. Social Stratification**

The pattern of distribution of economic, honorific, and political variables within the populations of complex societies; the allocation of personnel to the roles in question, notably through occupational mobility; and the impact of such processes upon behavior, both individual and social. Prerequisite: junior standing and Sociology 400, Introductory Sociology. 4 credits.

### **751. Sub-Saharan African Social Systems**

The stress will be on the analysis of segmentary and non-segmentary systems in terms of their variation throughout the continent. The focus will be on "how" these societies solve the problems of daily living in terms of the tribe, clan, and lineage. Prerequisite: Sociology 400 or 411, Introductory Sociology or Cultural Anthropology. 4 credits.

### **752. Social Problems in Modern Africa**

The focus will be on urban and rural adjustments (acculturation) of tribal systems in Africa (below the Sahara) to the 20th century. This course is a follow-up of Sociology 751 although the latter is not a prerequisite. Prerequisite: Sociology 400 or 411, Introductory Sociology or Cultural Anthropology. A background in sociological theory and methods is desirable. 4 credits.

### **755. Ethnography of Southeast Asia**

The geographical, racial, cultural and historical factors in the development of the area, together with detailed examinations of selected peoples and aspects of their culture. Prerequisite: Sociology 411, Cultural Anthropology, or permission of instructor. 4 credits.

### **761. Population Dynamics**

Examination of major population trends including changes in birth and death rates, population characteristics, mobility, migration, world population growth, population problems, and policies of countries at different stages of economic development. Emphasis is on the interrelationship of population and society. 4 credits.

**770. Culture, Personality, and Society**

Emergence of personality from the matrix of genetic, situational, and socio-cultural determinants viewed in cross-cultural perspective; dynamic interplay of the sociocultural and psychological behavioral systems. Prerequisite: any two courses from Sociology 400, 411, or Psychology 401, Introductory Sociology, Cultural Anthropology, or Introduction to Psychology. 4 credits.

**780. Social Conflict**

The nature of social conflict, especially war, will be investigated. The setting and initiation of conflict, its dynamics, and the factors affecting its course and outcome will be analyzed. Prerequisite: permission of instructor. 4 credits.

**785. The Study of Work**

This course is centered on the assumption that to understand society, one needs to understand the structure of work. Case studies of high-status and low-status occupations are used as clues to a larger perspective—an awareness of social processes and interrelationships in the social structure. The student is encouraged to study occupations in an ethnographic manner. Graduate students may enroll only with permission of instructor. 4 credits.

**801. Sociological Methods I. Intermediate Social Statistics**

Application of descriptive and inductive statistical methods to the analysis of sociological data, including sampling distributions, statistical decision-making, analysis of variance, correlation and regression, and nonparametric measures. Prerequisite: Sociology 701 or permission of instructor. 4 credits.

**802. Sociological Methods II. Research Design**

Systematic investigation of each step in the design and implementation of sociological research. Selected techniques of data collection and analyses will be pursued. Prerequisite: Sociology 701 and 702 or their equivalent, or permission of instructor. 4 credits.

**803. Sociological Methods III. Special Problems in Methods and Statistics**

Attention is focused on one or more special problems in sociological research such as the following: measurement and scaling, field and laboratory experiments in sociology, multivariate analysis, historical methods, community studies, mathematical models in sociological research, and survey design and analysis. Prerequisite: Sociology 801 and 802. 4 credits.

**805. Sociology as a Profession**

Sociological analysis of teaching and research in sociology, including the social organization of the discipline and social-psychological aspects of careers in sociology. Although primarily a seminar on the sociology of science and the sociology of education, the materials covered also provide professional orientation for a career in sociology. Prerequisite: a year of graduate study in sociology. 4 credits.

**811. Sociological Theory I**

The content, presuppositions, and implications of the body of sociological theory, exemplifying the full range of sociological inquiry. Prerequisite: Sociology 711 and 712 or their equivalents. 4 credits.

### **812. Sociological Theory II**

The content, presuppositions, and implications of contemporary sociological theory. The student will engage in theory construction and analysis, and in this endeavor will be encouraged to develop his particular interests in substantive areas. Prerequisite: Sociology 811. 4 credits.

### **813. Sociological Theory III**

A seminar of intensive study of specific figures and movements in sociological theory. Sample topics include: Max Weber; evolution, pragmatism, and reform; and classical social theory. Prerequisite: Sociology 711 and 712 or their equivalents. 4 credits.

### **821. Deviant Behavior**

A seminar in which attention is directed to the relationships among cultural, subcultural, and personality variables and deviant behavior. Special emphasis is placed on the following forms of deviant behavior: invention, crime, alcoholism, and emotional illness. Prerequisite: permission of instructor. 4 credits.

### **830. The Small Group**

The small group as a unit for sociological study, for the testing and the developing of hypotheses. Both the behavioral and the attitudinal levels shall be considered with respect to group intraaction and group-to-group interaction. The effects of different independent variables upon group structure shall be of particular interest. Prerequisite: A course in social psychology, or permission of instructor. 4 credits.

### **838. Sociology of Education: Social Organization of Schools and Community**

This course emphasizes viewing schools in their socio-cultural context; it is centered on a number of field studies of urban and suburban communities. Among the topics discussed are the following: (a) Comparative institutional analysis—what is church-like, hospital-like, factory-like, and prison-like about the school; (b) relations and perspectives of functionaries and clients in culturally deprived and culturally endowed settings; and (c) teaching as an emergent profession. 4 credits. (Also offered as Education 838.)

### **852. Socialization and Abnormal Behavior**

A seminar concerned with socialization and the effects of socialization on abnormal behavior. A survey of those orientations that relate socialization to abnormal behavior with the aim of synthesizing the major concepts into current sociological and social-psychological frames of reference. In addition, emphasis will be placed on the methodological problems of research concerned with socialization. Prerequisite: at least one course in social psychology or permission of instructor. 4 credits.

### **854. Sociology of Religion**

Critical analysis of the reciprocal relationship of religion and culture; the function of religion in society; the contributions of sociological research; the relationship between religion and other social institutions; religion and social change, and the problem of church and state. 4 credits.

**861. Demography**

Survey and analysis of current problem areas in demography, including: fertility, mortality, migration, population growth, population theory, formal demography, and the use of demographic sources and techniques in sociological investigation. Prerequisite: Sociology 761 or permission of instructor. 4 credits.

**870. Comparative Institutional Analysis**

Theoretical and methodological aspects of cross-national, comparative research in sociology, including: history of comparative research, examination of differences in objectives and methods employed, problems of translation and conceptual equivalence of behaviors and indexes, and field techniques. Prerequisite: Sociology 701 and 702. 4 credits.

**871. Social Institutions of Latin America and the Caribbean**

Selective analysis of distinctive institutions and social systems, with particular attention to social aspects of the process of modernization. Prerequisite: permission of instructor. 4 credits.

**885. Occupations and Professions**

Professionalization is discussed as adult socialization, an acquisition of a new identity; professions are explored as ideologies and as extended families. Low-status and high-status occupations are compared with regard to the way their members are recruited and trained, their career stages, work problems, and role-sets. A symbolic interactionist approach is adopted; issues of work are considered in their socio-cultural and institutional contexts; a number of the Chicago studies of occupations are examined. 4 credits.

**888. Sociology of Education: The Cultures of Poverty and Affluence**

The two cultures are treated as a unit; culture change is discussed. Issues of current interest are explored, e.g., poverty, school desegregation, the schooling of geographically-mobile children, problems of social mobility and abundance, the rise of the counseling and healing trades, and teachers' quest for professionalism. The education of culturally deprived and culturally endowed children receives special attention. A comparative approach is adopted; issues are examined cross-culturally and in relation to the schooling process. 4 credits. (Also offered as Education 888.)

**895, 896. Reading and Research in Sociology and Anthropology**

A student prepared by training and experience to do independent work under the guidance of an instructor may register for one or more of the following sections: (1) communications, (2) criminology, (3) cultural/social anthropology, (4) culture change, (5) culture and personality, (6) deviant behavior, (7) prehistoric archeology, (8) family, (9) population, (10) rural-urban, (11) social control, (12) social differentiation, (13) social movements, (14) social psychology, (15) social research, (16) social theory, (17) anthropological linguistics. Prerequisite: 16 graduate hours of sociology and permission of instructor. Hours and credit to be arranged.

**897, 898. Special Topics Seminar**

Under the direction of members of the department on the basis of rotation and interest, seminars are offered in those fields listed under Sociology 895, 896. Prerequisite: permission of instructor. 4 credits.

### 899. Master's Thesis

Usually 6 credits, but up to 10 credits when the problem warrants.

### 999. Doctoral Research

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## Soil and Water Science (23)

Chairman: *Gordon L. Byers*

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PROFESSOR: Gordon L. Byers

ASSOCIATE PROFESSORS: Francis R. Hall, Nobel K. Peterson

ASSISTANT PROFESSORS: Glendon W. Gee, Robert D. Harter

Students admitted to graduate standing in Soil and Water Science are required to have had adequate preparation in chemistry, physics, mathematics, and the biological or earth sciences. The major fields for graduate study are soil chemistry, soil physics, and hydrology; however, combined or more flexible programs may be arranged. A candidate for the Master's degree shall pass an oral or written examination covering his graduate courses and thesis.

Students interested in the Soil and Water Chemistry Option in the Chemistry Department's Ph.D. program should refer to pages 47 and 101.

### 701. Physics of Soils

Physical properties of soils in relation to their composition, formation, classification, and use as a vital resource. Structure, texture, water retention, and heat transfer in relation to plant growth. Methods of soil physical analysis. Mr. Gee. Prerequisites: 1 year of physics and 1 year of calculus. 3 lectures; 1 laboratory; 4 credits.

### 702. Chemistry of Soils

Chemical properties of soils in relation to their composition and use as a vital resource. Colloidal phenomena and their relation to exchange and fixation of elements in soil. Major topics include: cation exchange capacity and source of negative charge, the nature of soil acidity, the chemistry of nitrogen and phosphorus in the soil, and modern methods of soil chemical analysis. Laboratory sessions are designed to acquaint the student with analytical methods commonly used in soil chemistry. Mr. Harter. Prerequisite: Quantitative Analysis or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

### 703. Soil and Water Engineering

The treatment of engineering principles relating to the control of water. Major topics include precipitation and stream-flow measurement, estimating run off from a watershed, and the design of structures to control this runoff. Subsurface drainage and irrigation systems are studied in detail. Laboratory sessions are designed to acquaint the student with instrumentation and problem analysis. Mr. Byers. Prerequisite: permission of instructor. 3 lectures; 1 laboratory; 4 credits.



### 704. Soil Classification

Soils are studied in relation to the genesis, morphology, and classification including the current U.S.D.A. soil classification system. The five major factors affecting soil development are reviewed in detail as are the soils found in the United States with special attention on New Hampshire. Emphasis is placed on the importance of chemical and physical characteristics. Mr. Peterson. Prerequisites: Soil and Water Science 501 and a basic geology course or permission of the instructor. 3 lectures; 1 laboratory; 4 credits. (Alternate years.)

### 705. Principles of Hydrology

A study of the physical and chemical processes involved in the movement of water through the rainfall-runoff segment of the hydrologic cycle. Major topics include infiltration and percolation, overland and channel flow, channel processes, and the nature of the stream-discharge record or hydrograph. Laboratory sessions involve the use of a demonstration channel, electrical and fluid models, and selected problems to demonstrate important principles. Mr. Hall. Prerequisites: 1 year of geology and 1 year of calculus. 3 lectures; 1 laboratory; 4 credits.

### 709. Soils and Community Planning

A "Town Plan" and a soils map are studied by students to develop individual reports of land use. The course includes an introduction to the soils of New Hampshire, basic information on the U.S.D.A. soil classification system, and the Soil Conservation Service criteria for rating soils for multiple use: housing, recreation, sewage effluent disposal, conservation, transportation, surface runoff, and other soil-use problems common to many rural and urban communities. A representative of a town planning firm and federal and state soil scientists are guest lecturers. Mr. Peterson. 2 lectures; 2 credits.

### 710. Ground-Water Hydrology

Introduction to the principles governing the occurrence, location, and development of ground water. Major topics include well hydraulics, geophysical exploration, and chemical quality of water. Brief treatment given of water law and economics. Laboratory sessions are designed to illustrate principles by use of fluid and electrical models, geophysical instruments, and selected problems. Mr. Hall. Prerequisite: Soil and Water Science 703 or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

### 801. Advanced Soil Physics

The physics of unsaturated water flow. Theory of infiltration and drainage. Application of unsaturated water-flow theory to soil-plant-atmosphere systems. Mr. Gee. Prerequisite: permission of instructor. 3 lectures; 3 credits.

### 802. Advanced Soil Chemistry

Physical chemistry of soils and soil colloidal phenomena. Anion and cation exchange mechanism in soils. Theories of swelling. Crystallographic properties of the clay colloids and their relation to cation and anion exchange. The nature of soil acidity. Oxidation-reduction phenomena in soils. Mr. Harter. Permission of instructor. 3 credits.

### 803. Advanced Ground-Water Hydrology

Application of analytic techniques to ground-water systems. The emphasis is on development of mathematical, statistical, and graphical methods that can

be applied to selected problems. Major topics include radial flow to wells, lateral flow to streams and drains, flow-set analysis, and simulation methods including fluid models, electric analog models, and digital computers. Brief treatment given of multiple-well problems and two-phase, fluid-flow systems. Mr. Hall. Prerequisite: Soil and Water Science 710 or permission of the instructor. 2 lectures; 1 laboratory; 3 credits.

### 804. Hydrochemistry

The chemical principles for dilute aqueous solutions at relatively low temperatures and pressures are applied to the study of fresh waters at or near the earth's surface. Major topics include equilibrium concepts, buffering mechanisms, oxidation-reduction reactions, and ion exchange. Particular emphasis is given to selected systems involving water, carbon dioxide, calcium carbonate, and silicate minerals. Laboratory exercises utilize simple experiments to give experience with methods of measurement and interpretation of results. Mr. Hall. Prerequisite: 2 years of chemistry or equivalent or permission of instructor. 2 lectures; 1 laboratory; 3 credits.

### 895-896. Investigations in Soil and Water Science

Offered in: (1) Soil-Plant Relationships, Mr. Peterson. (2) Physics of Soils, Mr. Gee. (3) Hydrology, Mr. Byers and Mr. Hall. (4) Chemistry of Water, Mr. Hall. (5) Chemistry of Soils, Mr. Harter. (6) Soil Classification, Mr. Peterson. Elective only after consultation with the instructor in charge. 14 credits.

### 899, (899). Master's Thesis

6-10 credits.

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## Spanish and Classics

Chairman: *Michael S. Pincus*

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PROFESSOR: R. Alberto Casas

ASSOCIATE PROFESSORS: Richard J. Callan, Charles H. Leighton, Michael S. Pincus

The Department of Spanish and Classics offers courses leading to two degrees in Spanish, the Master of Arts and the Master of Science for Teachers. To be admitted to graduate study for the Master of Arts degree in Spanish, a student must have met requirements substantially equal to those set up for an undergraduate major in that language at the University. In addition, all candidates for admission to the graduate program in Spanish must take the general Graduate Record Examination and the advanced test in Spanish. To obtain the degree, the student must fulfill the course requirement and submit an acceptable thesis.

To satisfy the course requirement, he must complete at least eight courses of three or more credits from the courses listed below (6 credits are granted for the thesis thus completing the total of 30 required by the Graduate School).

To take a course numbered 850-898, a student must register for the corresponding undergraduate course numbered 750-798, pass it with a grade of B or better, do supplementary work assigned by the instructor, and prepare a paper of graduate quality on a topic assigned by the instructor. No student may register for a graduate course if he has already taken the corresponding undergraduate course here or its equivalent elsewhere.

Before undertaking work on the thesis, the student must pass a comprehensive written examination. The examination will be given four times a year: in January, May, August, and September. The candidate will be permitted to take the examination only twice. If he fails in his first attempt, he must wait at least three months before taking it again. The thesis must embody the results of independent investigation and be written in a form acceptable to the department. It must be submitted to the thesis director before April 20 of the academic year in which the degree is to be granted.

To be admitted to graduate study for the Master of Science for Teachers degree in Spanish, a candidate must have satisfactorily completed the requirements for secondary school teacher certification in the language. To obtain the degree, he must complete 30 semester hours of work at the graduate level. Since it is intended for teachers already in service, courses leading to this degree will normally be chosen from Summer Session offerings. Secondary school teachers interested in this degree should consult the Department Chairman.

### Spanish (62)

#### 701, 702. Catalan

An introduction to Catalan grammar and literature. Semester I: study of the linguistic elements of Catalan, especially in its contrasts with other Romance languages, and basic readings in Catalan. Semester II: a survey of Catalan literature from the Middle Ages to the present. Prerequisite: completion of an intermediate-level course in Latin or one of the Romance languages, or permission of the instructor. 4 credits.

#### 707, 708. Comparative Literature

For 1970-71, a study of the European novel of the 20th century, taught by members of the faculty of the Departments of English, French and Italian, German and Russian, and Spanish and Classics. 4 credits.

#### 801. Bibliography and Methods of Research

Required of all graduate students in their first year of study. An introduction to standard bibliographical techniques, to form and style in the preparation and writing of research findings, and to the use of computers in research in the Spanish language and literatures. Preparation of a research paper. 1 credit.

#### 803. Applied Linguistics

Required of all graduate assistants teaching in the departmental program, but open to all graduate students in Spanish. Discussion of current methodology and linguistic approaches to the teaching of Spanish. Instruction in the use of audio-visual aids, including language laboratories. Readings, discussion, class observation. 1 credit.

#### 811. Medieval Spanish Literature

Study of a topic or topics in Spanish literature of the period 1100-1500. Works normally to be studied include Berceo, the *Libro de buen amor*, the poetic schools of the 15th century, and *La Celestina*. Social and historical backgrounds of the period. Conducted in Spanish. 3 credits. (Offered alternate years.)

### 831. River Plate Literature

Sarmiento, José Hernández, Rodo, Florencio Sánchez, Mallea. Focus on the question of *argentinidad*. Conducted in Spanish. 3 credits. (Offered alternate years.)

### 852. Drama and Poetry of the Siglo de Oro

The social background of the baroque period. Readings of representative plays of Lope de Vega, Tirso de Molina, Calderon, and the poetry of Lope, Gongora, and Quevedo. Development of the prose of the period. Conducted in Spanish. 3 credits.

### 854. Cervantes

The development of Cervantes' literary art. Reading and discussion of selections from all the major works of Cervantes. Comprehensive study of the *Quijote*, its originality and significance; its antecedents; its religious, philosophical and sociological aspects; and its artistic structure. Conducted in Spanish. 3 credits.

### 855. Literature of the Nineteenth Century

Readings and discussion of works by significant writers of the nineteenth century in Spain, such as Larra, Espronceda, Bécquer, Pérez Galdos, and Blasco Ibáñez, within the artistic, philosophical, and social environment of the century. Conducted in Spanish. 3 credits. (Offered alternate years.)

### 857. Theater and Poetry of the Twentieth Century

Critical analysis, reports, and discussion of the major developments in poetry and the drama of the twentieth century, beginning with the Generation of '98. Major writers to be studied will include Benavente, Machado, J. R. Jiménez, García Lorca, Casona, Sastre, Buero Vallejo, Dámaso Alonso, and Miguel Hernández. Conducted in Spanish. 3 credits. (Offered alternate years.)

### 858. Spanish Prose of the Twentieth Century

Readings and discussion of the novels, short stories, and essays of such major writers of the twentieth century as Unamuno, Baroja, Menéndez Pidal, Ortega y Gasset, Julián Marias, Aranguren, Pérez de Ayala, Gironella, and Cela, as well as a survey of contemporary prose. Conducted in Spanish. 3 credits. (Offered alternate years.)

### 860. Unamuno and Ortega y Gasset

Critical examination of the philosophical ideology and literary content of the major contributions of Miguel de Unamuno and José Ortega y Gasset. 3 credits. (Offered alternate years.)

### 871. Spanish-American Drama

From pre-Hispanic origins to the present, with emphasis on the modern playwrights of Mexico and Puerto Rico. Conducted in Spanish. 3 credits. (Offered alternate years.)

### 872. Spanish-American Novel

Development of the genre from Romanticism to present-day writers, with special emphasis on contemporary trends and techniques. Conducted in Spanish. 3 credits. (Offered alternate years.)

**873. Spanish-American Short Story**

Development of the genre through study of representative authors, with stress on the twentieth century. Principles of interpretation. Conducted in Spanish. 3 credits. (Offered alternate years.)

**874. Spanish-American Poetry**

Discussion of major poets from *modernismo* to the post-Vanguard movements: Darío, Huidobro, Mistral, Vallejo, Octavio Paz. Conducted in Spanish. 3 credits. (Offered alternate years.)

**891. Spanish-Education: Problems in the Teaching of Spanish in the High School**

The special objectives, methods, and devices of modern-language teaching in high school. For prospective or actual teachers of Spanish. Prerequisite: intermediate Spanish; and grade of C or better in Education 648 or one year's teaching experience. 3 credits.

**895, 896. Special Studies in Spanish Language and Literature**

Individual guided study in special topics, with training in bibliography, note taking, and organization of material. Staff. Conducted in Spanish. Prerequisite: permission of Department Chairman. Variable credit.

**899. Master's Thesis**

6 credits.

## Technology (79)

Dean: *Richard S. Davis*

**601. Statistical Methods in Engineering and Physical Science**

Methods of organizing data and statistical techniques for data analysis, as applied to problems in engineering and physical science. Elementary probability theory and probability distribution. Correlation and regression analysis. Design of experiments; factorials, fractional factorials, designs for process optimization. Introduction to quality control; construction and analysis control charts for variables and attributes; statistical aspects of tolerance. 4 credits.

## Zoology (70)

Chairman: *Langley Wood*

PROFESSORS: Wilbur L. Bullock, Lorus J. Milne, Philip J. Sawyer, Emery F. Swan, Langley Wood, Paul A. Wright

ASSOCIATE PROFESSORS: Arthur C. Borrer, Frank K. Hoornbeek, Marcel E. Lavoie, John J. Sasner, Paul E. Schaefer

ASSISTANT PROFESSORS: Robert A. Croker, John E. Foret, Edward N. Francq, Edward K. Tillinghast

The graduate program in Zoology is intended for the student who aspires to a professional career of scholarly research and teaching at the college level. The graduate program in Biology is designed for teachers in secondary schools.

Hence to be admitted to graduate study in Zoology, a student must have completed an undergraduate major in biology or zoology. In addition to a basic array of courses in the major field, applicants should have a satisfactory background in botany, chemistry, mathematics and physics. Two foreign languages (usually French, German, or Russian) or the equivalent are also necessary, and satisfaction of the language requirement is prerequisite to candidacy for the degree of Doctor of Philosophy. Students who are deficient in any of these requirements may sometimes be admitted to graduate status but may be required to remedy their deficiencies by taking courses which do not give graduate credit.

All beginning graduate students in Zoology will be required to pass an examination, both written and oral, in General Biology plus four of the following eight fields: Behavior, Biochemistry and Physiology, Development, Ecology, Evolution and Systematics, Genetics, Morphology, and Parasitology. Normally, this examination will be passed by the end of the second year of graduate work, but *must be taken* during the first year following enrollment. This examination may function in partial satisfaction of the Master's degree requirements, or to identify academic deficiencies in students who wish to proceed to doctoral candidacy. If the deficiencies revealed are regarded by the Zoology faculty as sufficiently serious, the student's tenure may be terminated, or he may be allowed a second examination after additional preparation.

A candidate for the Master of Science degree in Zoology, in addition to the requirements mentioned above, will ordinarily elect to complete a special problem (Zoology 895 or 896) or a thesis that is acceptable to his guidance committee.

In addition to the language requirements, and after the successful completion of all required courses, the student who wishes to be admitted to doctoral candidacy must demonstrate a broad basic knowledge of his major and minor fields in a written and oral qualifying examination, administered by his doctoral committee. In addition, he must convince his proposed major professor and doctoral committee, in whatever way the committee finds acceptable, of his superior capacity to carry out basic research in biology. Normally, the student may accomplish this by presenting to his committee a research proposal in which the soundness, originality, and feasibility of his investigative ideas are clearly revealed, and which—when approved—should serve as the basis of his doctoral dissertation.

### (700). Research Methods

A workshop introduction to the process of biological investigation. Includes presentations of current research by members of the Zoology faculty; critical discussions of the philosophy of science generally and of biological concepts specifically; methods and practice in literature search and the handling of bibliographic data; lectures and laboratories in scientific writing. Each student will prepare written and oral presentations of a review of a selected biological topic. Required of all beginning Zoology graduate students. Mr. Wood and Staff. 4 credits.

### 703. Genetics

A course intended for students desiring a more detailed training in fundamental genetics. Required for genetics students; elective for others. Mr. Hoornbeek. Prerequisite: Zoology 604, Principles of Genetics, or equivalent. 4 credits. (Not offered 1970-71.)

**704. Comparative Endocrinology**

The various endocrine organs are considered in their relationship to control of the internal environment, growth, development, and adaptation to the external environment. Mr. Tillinghast. Prerequisite: vertebrate anatomy and physiology, and organic chemistry. 4 credits.

**711. Natural History of Cold-Blooded Vertebrates**

The various classes of poikilothermic vertebrates, their habits, habitats, and life histories, with special reference to those occurring in eastern North America. Mr. Sawyer. Prerequisite: general zoology and Zoology 518, Vertebrate Morphology. 4 credits.

**(712). Mammalogy**

The origin and diversification of mammals, their ecology and economic importance. Laboratories will emphasize techniques of the mammalogist and identification of local forms. Mr. Francq. Prerequisite: general zoology and Zoology 508, Human Anatomy and Physiology. 4 credits.

**(713). Animal Behavior**

Individual and group behavior of animals, including the role of anatomy, physiology and prior experience, and the ecological significance of these patterns. Techniques and the practical application of the study of animal behavior. Mr. Francq. Prerequisite: one year of zoology. 4 credits.

**715. Natural History of Marine Invertebrates**

A field and laboratory course designed to acquaint the student with the inshore marine invertebrate metazoan animals of northern New England. Emphasis will be on identification, classification, habitat preferences, and behavior of these animals. Field work (collection and observation) will constitute a major part of the course and the student must be prepared to assume some travel expense. Staff. Prerequisite: general zoology. 4 credits. (Offered in Summer 1970.)

**721. Parasitology**

An introductory course in some of the more important parasites causing disease of man and animals. Living materials will be used as far as possible. Mr. Bullock. Prerequisite: one year of zoology. 4 credits.

**723. Cell Physiology**

Application of the principles of chemistry and physics to the understanding of cell structure and function. Metabolic reactions and their control are considered in relation to cell organization. Treatment is also given to the genesis and function of specialized cells. Mr. Tillinghast. Prerequisite: organic chemistry. 4 credits.

**726. General Physiology**

A study of some of the physical and chemical phenomena common to all biological systems. Special emphasis is placed on membranes, permeability, excitability, conductivity, contractility and bioenergetics. Mr. Sasner. Prerequisite: organic chemistry, physics, and one year of zoology. 4 credits.

**729. Vertebrate Morphogenesis**

The fundamental principles of vertebrate growth and development including embryology, metamorphosis, and regeneration. Mr. Foret. Prerequisite: general zoology. 4 credits.

### **772. Fisheries Biology**

Designed to introduce the student to some of the information and techniques used by the freshwater fisheries biologist. Emphasis on freshwater fisheries, but many of the techniques and some of the reading pertain as well to salt water fisheries. Mr. Sawyer. Prerequisite: Zoology 711 or equivalent, and permission of instructor. 4 credits.

### **795, 796. Special Problems in Zoology**

Election of one or more sections of this course provides opportunity for advanced study. Section numbers and subject-matter fields are: (1) Biological Oceanography, (2) Ecology, (3) Endocrinology, (4) Evolution, (5) Developmental Biology, (6) Genetics, (7) Histology, (8) History of Zoology, (9) Invertebrate Zoology, (10) Physiology, (11) Vertebrate Zoology, (12) Zoogeography, (13) Zoological Techniques, (14) Parasitology, (15) Histochemistry, (16) Protozoology, (17) Systematics, (18) Animal Behavior. Work may involve reading, laboratory work, organized seminars, and/or conferences. Prerequisite: permission of staff concerned. 2 or 4 credits. (Limit of 12 credits from the sections of this course.)

### **801. Freshwater Ecology**

An introduction to some of the chemical, physical, and biological facets of the special relationships between freshwater organisms and their environment. Laboratories will include limnological techniques and others necessary for analyzing the variations in freshwater habitat. Mr. Sawyer. Prerequisite: Biology 641 or equivalent; courses in physics, chemistry, invertebrate and vertebrate zoology, geology, algology, and aquatic entomology are desirable. 4 credits. (Not offered in 1970-71.)

### **(803). Marine Ecology**

The marine environment and its biota, with emphasis on intertidal and estuarine habitats. Laboratory and field work will stress inquiry and the application of ecological, physiological, behavioral, biometrical, systematic, and chemical techniques to local problems. Field trips may be scheduled for early morning, late afternoon, or weekends. Travel will be at student's expense, and should not exceed \$30 for the course. Mr. Croker. Prerequisite: Biology 641, General Ecology, and permission of instructor; courses in marine invertebrate zoology, oceanography, and statistics are desirable. 4 credits.

### **806. Biological Oceanography**

An introduction to oceanic ecology: the dynamics of marine populations, studied in a context of the physical, chemical and geological processes and conditions that are characteristic of the open sea and deeper benthic habitats. Field experiences will include short cruises in the Gulf of Maine aboard R/V "Jere A. Chase" and, usually, a more extended cruise in the Gulf Stream and Sargasso Sea regions aboard R/V "Eastward." Mr. Wood. Prerequisites: Geology 501, Introduction to Oceanography, and permission of instructor. 4 credits.

### **(820), (821). Advanced Invertebrate Zoology**

A detailed and comprehensive study of the morphology, phylogeny, and natural history of the major invertebrate phyla in lecture and laboratory. Staff. Prerequisite: Zoology 618, Introduction to Invertebrate Zoology, or equivalent. 4 credits.



**(822). Protozoology**

The general biology of Protozoa with particular emphasis on morphology, natural history, and economic importance. Mr. Borrer. Prerequisite: Zoology 721 or 820 or permission of instructor. 4 credits. (Not offered in 1970-71.)

**823. The Host-Parasite Relationship**

Examination of the interactions of host and parasite, using examples from fish, wildlife, and human parasitology. Particular attention will be given to ways in which host ecology influences parasite populations, and the interplay of host and parasite in parasite pathology and immunology. Mr. Bullock. Prerequisite: previous training in parasitology, histology, and ecology desirable. 4 credits. (Not offered in 1970-71.)

**(824). Advanced Parasitology**

The morphology, life cycles, and systematics of the protozoan and helminth parasites of local fishes with particular reference to the estuarine environment. Mr. Bullock. Prerequisite: Zoology 721. 4 credits.

**826. Comparative Physiology**

The means whereby animals, chiefly invertebrate, have met the problems of irritability, nutrition, maintenance of a constant internal environment, and reproduction. Mr. Sasner. Prerequisite: Zoology 725. 4 credits. (Not offered in 1970-71.)

**828. Experimental Embryology**

An examination of cellular differentiation during developmental processes. Laboratories will illustrate important techniques in experimental morphogenesis. Mr. Foret. Prerequisite: Zoology 729 or equivalent. 4 credits. (Not offered in 1970-71.)

**830. Invertebrate Embryology**

The developmental patterns as exhibited by the major invertebrate groups. This will be essentially a descriptive study based upon lectures, library, and laboratory work with living material. Mr. Foret. Prerequisite: Zoology 820, 821. 4 credits. (Not offered in Summer, 1970.)

**895, 896. Advanced Studies in Zoology**

The sections of this course provide opportunity for advanced work either on an individual or group seminar basis. They may involve reading, laboratory work, organized seminars, and conferences. Prerequisite: permission of Department Chairman and staff concerned. (Sections of this course are the same as those listed under Zoology 795, 796.) 2 or 4 credits.

**897, 898. Zoology Seminar**

Preparation, presentation, and discussion of reports of recent zoological literature. Subject matter fields are the same as those listed under Zoology 795, 796. Not all areas will be available every semester. Required of graduate students in zoology. Staff. No credit.

**899. Master's Thesis**

Open to students who wish to do independent, original research. Prerequisite: permission of Department Chairman and prospective supervisor. 6 credits.

**999. Doctoral Research**

Open to students who have declared their intention of proceeding to candidacy for the Doctor of Philosophy degree.



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